Mechanical World — July 1958

Impetus for Hydraulics

AN unusual but instructive way of comparing terrestrial energy resources is to examine them in relation to the dimensions to which they are attached. To see the essential difference it is not necessary to make an exhaustive analysis; the quite evident differences are sufficient to reveal their categories. Coal, oil and uranium, for instance, are present in the earth in a finite quantity, whereas the quantity available from water power will only be determinable when the time of its availability is known, and that is likely to be longer than the time of habitability of the earth. Not enough is known of the new process of fusion of the light atoms to set it in its proper relationship; certainly it is imagined to be vast beyond all comparison with the other known sources, but whether it is spatial or whether it also has a time element remains to be discovered. Until the fusion process is practicable, the bulk of energy must be obtained from the other four sources—coal, oil and uranium on the one hand, and water power on the other. They do not exhaust the list, but they are by far the most important.

Oil, coal, uranium. That is an ascending order of quantity. Dividing the quantity by rate of usage gives respective lives for the three sources of decades, centuries and millenia. The significant difference with water power is that its life will be as long as the weather. For example, when a lake of oil is struck it is pumped dry and that is the end of it, but when a lake of water is run out through turbines the lake does not remain dry—it is constantly replenished. It may require the aid of several tons of water to generate the amount of energy obtainable by the combustion of a pound of oil, but the first is a continuous process whereas the second is for once only. The comparison applies equally with other known natural fuels. The practical limit to the expansion of water power is thus seen to be uniquely the harnessing of the rate of output, and not its ultimate quantity—make any guess at what the ultimate quantity potential might be and it will be seen to be very large.

There is a long way to go before all the available water power is put to use. Thirty years ago the chart of the world's water power resources could have a small dot showing the total share of the United Kingdom, yet it has been found worthwhile to build extensive schemes in the Scottish and Welsh Highlands. Such smaller possibilities are much more numerous than the few spectacularly large schemes. Even so, as Messrs. J. C. Beverley, E. G. Teasdale, and A. Wilmot, all of The English Electric Company Limited, said at the 10th British Electrical Power Convention, in no country other than Western Germany, Italy and Switzerland is the potential more than 50% utilized and in the majority of countries utilization is below 25%. They gave the anticipated annual demand in the free world for new hydro-electric plant in three years time as 10,500 MW.

Apart from this quite fundamental position of the hydro-electric generator, it is clearly destined for an additional role in conjunction with nuclear power. All the indications are that the nuclear reactor will remain as a heat generator and that the steam turbine will flourish alongside it as the means of generating electricity. It is characteristic of the nuclear power plant that it is limited to base load working. This means that as more and more such plants are built an increasingly greater proportion of generating capacity will be subject to this limitation, but the need will remain for providing sufficient flexibility to meet peak load conditions. This can be done by fuel-fired or diesel stations, and also by hydro-electric power which is at the other end of the scale in this respect—it is the most flexible of all the primary sources of power. Where natural hydraulic power is insufficient, pumped storage on the lines of plants now under construction will be the answer. For very large nuclear plants the pumped storage installation alone could well take on all the features of a major project.

LOG SHEET

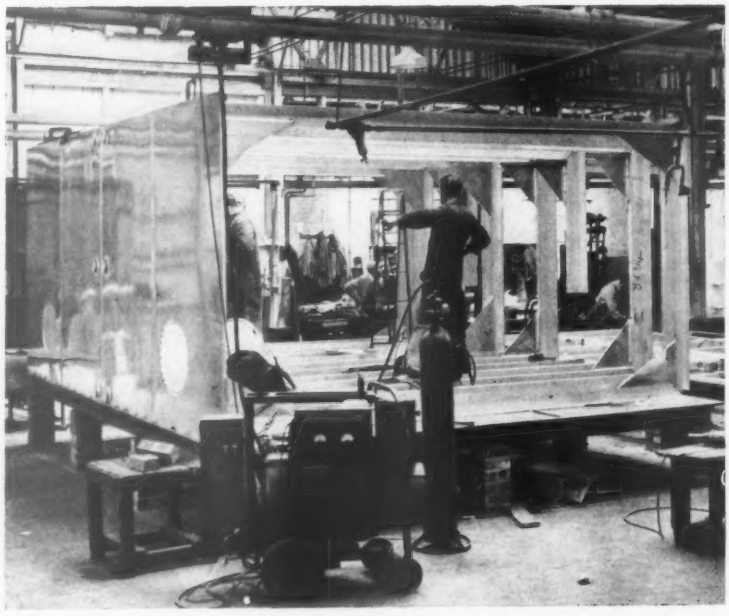
TV Aids N.P.L. Research

Observing the flow characteristics of model aircraft undergoing wind tunnel tests, in addition to measuring the forces arising, now enables aircraft designers to calculate flight performance with a high degree of accuracy. As the speed of aircraft has increased, however, bringing with it corresponding increases in landing speeds, it has become increasingly difficult to provide tunnels capable of reproducing the full-scale conditions required. One solution of this problem, which has been used successfully by the National Physical Laboratory at Teddington, is to employ a compressed air tunnel. Testing models in compressed air produces the same results as testing larger models in air at ordinary pressure for similar wind speeds.

In the past, however, considerable difficulty has been experienced in carrying out observations and taking photographs of models under test. Direct observations can only be made in the N.P.L. tunnel through three small plate glass windows measuring 2 in. dia. Now the difficulty is being overcome by installing a closed circuit industrial television channel, designed and manufactured by E.M.I. Electronics Limited, which will enable close observation to be kept of all models under test. A modified version of E.M.I.'s latest Mark VI camera channel is being installed. The camera unit has been built into a special housing capable of withstanding pressure of up to 370 psi.

In order that the greatest possible benefit should be derived from the use of a closed circuit television, it was essential that the pictures produced should be of the highest definition possible under the limited lighting available. Good definition was particularly important to enable photographs to be taken direct from monitor screens. The Mark VI camera is particularly suitable for this type of installation as it provides remote control facilities for iris, focus and turret. The camera used in the N.P.L. tunnel employs two lenses—one giving a horizontal field of view of about 40° and the other about 10°.

The camera is a completely new design and enables almost any installation to be carried out—from a simple single channel to a multiple camera job—using the same basic units. Particular attention has been paid in its design to operational simplicity, reliabilty and ease of preventative maintenance. Plug-in unit construction and printed circuit techniques have been extensively employed The 625 lines system is used but this can be modified to 405 lines if required. A Vidicon Type 10667G camera tube is used.



WATER TANKS.—The tank seen here under construction in the St. John's works at Worcester of Windshields of Worcester Limited is Argonaut welded of ¼-in. MG5 aluminium alloy plate and extrusions supplied by James Booth & Co. Limited, of Birmingham. The approximate dimensions are 18 ft × 13 ft × 7 ft. A second tank of about the same capacity and of slightly different dimensions is also being made. The tanks are for holding fresh water aboard two new Caltex tankers

New Sinter Plant

Workington Iron and Steel Company, a branch of The United Steel Companies Limited, are to spend £2½ million on a new single strand continuous sinter plant. Designed to produce 12,500 tons of self-fluxing sinter per week for the company's blast furnaces, the plant is being supplied by Head, Wrightson and Company Limited, and is expected to be in operation by the end of 1960.

In the material storage building, which will form part of the plant, stock bays are to be provided for approximately 40,000 tons of ore fines and material bins will be arranged in line parallel to the storage yard. Conveyor belt systems will bring the fines to the stock bays and material bins, and an overhead grab crane will transfer the ore from the bays to the bins when necessary. Coke breeze, which is also required in the sintering process, will be pulverized at the existing coke oven plant and a crusher house for crushing limestone is to be built adjacent to the material storage building.

Sinter mixture materials will be fed on to a gathering belt by 9 ft dia rotary feeder tables fitted with Ward Leonard control for speed adjustment but in addition the coke feeders will have an independent speed control. After primary mixing in a twin paddle rotary drum mixer, the mixture will pass to a surge hopper, fitted with a variable speed rotary feeder table. Finally, it will go through a pelletizing drum prior to distribution on the strand. Mixed blast furnace and coke oven gas will be used for ignition.

The 72 in. wide sinter machine will have an effective length of 168 ft over 28 wind-boxes, the strand being equipped with pallets

having 14-in. high side plates. The variable speed range of the strand will be from 45 to 170 in. per minute. Gas from the wind-boxes will be collected in a straight dust collector wind main of increasing cross-sectional area, the last 90-ft long section of which will act as a dust settling chamber.

Discharged sinter will pass through a breaker with 6-in. knife spacings to a Schenk vibrating screen. By means of a variable speed feeder, the + ¾-in. sinter will be fed to a Lurgi Frodingham circular cooler with a designed capacity of 100 tons per hour. The pallets in this cooler will discharge the sinter into a hopper for transfer via a variable speed feeder and a conveyor to the blast furnace high line car, which will unload in the furnace bunkers.

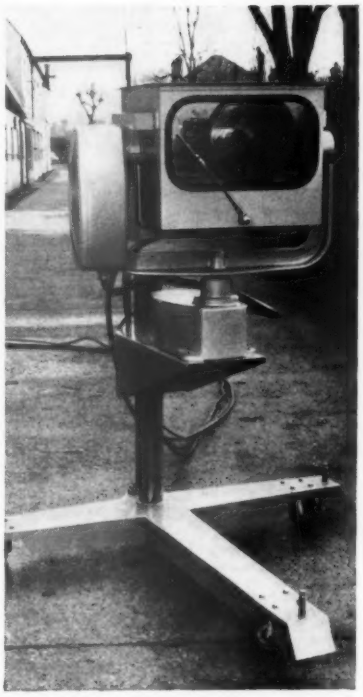
The hot −¾-in. sinter returns will be carried by tray conveyor from the sinter screen to a quenching station. Here, a Schenk screen mounted over twin bunkers will divide the returns into two size fractions, +⅜ in. for bedding material and −⅜ in. for use as return sinter. The bedding fraction, after cooling, will pass to a surge hopper with a rotary feeder table from which it will be fed to the sinter machine. The return sinter fraction will be transferred to the return fines storage bins in the material storage building.

Dust extraction equipment is to be provided to handle the dust from the discharge end of the sinter machine and from the sinter screen, cooler and quenching station areas.

Metropolitan-Vickers at Brussels

The Metropolitan-Vickers Electrical Company Limited have exhibits in two sections of the Brussels International Exhibition—the British Industries Pavilion and the Hall of Science.

Exhibits in the British Industries Pavilion are included in the British Electrical and Allied Industries joint display, and consist mainly of models. There are five scale model locomotives, a working model of a 120 MW turbine-generator, a transmission and distribution model, and two products of Metropolitan-Vickers—GRS Limited—a four aspect searchlight signal and multi-lamp route indicator. Metropolitan-Vickers Magistor photo-transistor relays are used to count the number of visitors to the stand and to the domestic section on the upper floor. There is also an oil painting of the A.E.I.–John Thompson Nuclear Power Station at Berkeley.



INDUSTRIAL TELEVISION.—A standard Pye industrial television camera which has been specially housed for outdoor observation at an explosives factory. The pressurized housing is weatherproof and explosive dustproof. The windscreen wiper, heavy-duty pan and tilt unit, lens change unit, pedestal height, monitor and control unit trolley and demisting device which blows warm air on the polished plate glass window are all remotely controlled

The company's principal exhibits in the Hall of Science is a mass spectrometer, which is used for the rapid accurate analysis of organic and inorganic gases and vapours, and a high-frequency plastics welder for use in the garment trade.

In connexion with the former a periodic table of isotopic abundance of the naturally occurring elements illustrates the relative abundance of the stable isotopes of the various elements. The most abundant isotope of an element is represented by a standard column of fixed height on a graph, and the remainder shown as columns whose heights are proportional to their abundance with respect to the standard. Where the abundance is less than 2% of the standard a small triangle has been used.

Rare earths and certain metals are shown outside the table for convenience. When the atomic number of an element is selected on the telephone type dialling mechanism the appropriate graph is illuminated for a short time.

Desulphurizing and Sulphuric Acid Plant

After ten years of experiments and pilot plant trials, Appleby-Frodingham Steel Company, a branch of the United Steel Companies Limited, have developed an entirely new combined desulphurizing and sulphuric acid plant which is claimed to incorporate major advances on any existing similar process. The first full-scale plant is now being installed at Appleby-Frodingham and is due for completion by mid-1959.

At most integrated steelworks, a certain proportion of coke oven gas is used to fire the open hearth melting furnaces, the remainder being used in reheating furnaces and soaking pits. This gas contains about 1% of sulphur which, apart from adding to the difficulties of making low sulphur steel, results in considerable quantities of sulphur dioxide being released into the atmosphere. In an integrated works making one million tons of steel ingots a year the use of the Frodingham desulphurizing process enables the sulphur dioxide to be recovered, from which as much as 250 tons of sulphuric acid can be produced each week.

In the case of ordinary gasworks supplying town's gas, there is a statutory obligation to reduce the sulphur content of the gas to the equivalent of less than two parts per million by volume of sulphuretted hydrogen, a necessity which entails the provision of costly and extensive purification plant. Even after this is done, however, there remains a residue of organic sulphur which cannot be removed in existing purification equipment, and which causes corrosion in domestic hot water and similar appliances.

The plant developed by Appleby-Frodingham, which consists essentially of a fluidized hot iron oxide absorber and regenerator, is capable of removing both hydrogen sulphide and organic sulphur to very low levels; at the same time, too, it enables the recovery of considerable quantities of sulphuric acid. The heat requirements of the plant are met by the combustion of the absorbed sulphur and, once started up, it is self-sustaining for heat.

A pilot plant has been in successful operation for two years, purifying up to three million cubic feet of coke oven gas per day. The full scale plant, when completed, will deal with 32 million cubic feet of gas per day.

Because the process employs hot gas, it is very much faster than conventional iron oxide boxes or purification towers, while the use of fluidized beds reduces the amount of spent oxide by four-fifths and simplifies its handlng and distribution. In compactness and capital cost, the process compares very favourably with existing methods, while the entire operation of the full-scale plant is capable of being handled by two men per shift.

Under the provisions of the Clean Air Act, the height of chimneys discharging sulphur dioxide to atmosphere may be subject to regulation and this, combined with the economic and technical factors already mentioned, suggests that the new Frodingham desulphurization process is likely to be of particular interest to the steel industry, the gas industry—especially in the case of the larger gasworks—and the chemical and petroleum industries.

Appleby-Frodingham have appointed two licensees to build plants based on this process. They are Henry Balfour & Co. Limited, of Leven, Fife, and W. J. Fraser & Co. Limited, of Romford, Essex. The unit at present under construction at the Appleby-Frodingham works is being built by W. J. Fraser.

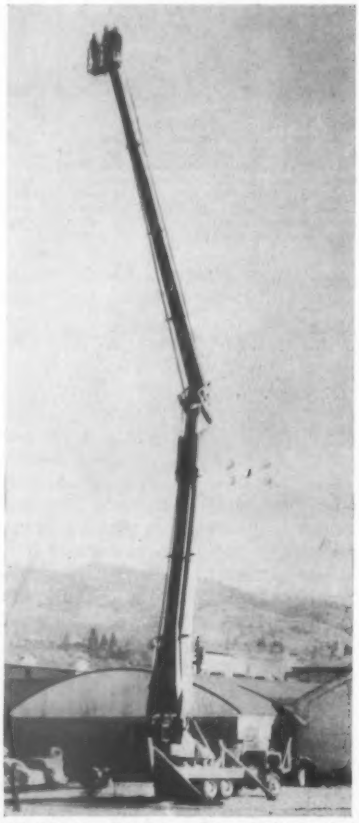
Welding Research on the Sno-cats

The fact that the welded tracks of the Sno-cats used in the Trans-Antarctic Expedition effectively withstood the severe conditions to which they were subjected is an interesting example of the advances in welding technology, resulting from research.

The weight of the Sno-cat is carried on four pontoons and traction is provided by a flexible track around each pontoon. The units of the tracks consist of two alloy steel castings, attached to the ends of a 2 ft length of medium carbon steel tube by welding. During proving and training runs of the vehicles in Norway, some of the welds in the track units cracked, causing failure of the tracks. When the vehicles returned to England, specimens of the failed units were submitted to the British Welding Research Association laboratories at Abington, Cambridge. Examination of the welds between the carbon steel tube and the alloy steel casting showed that the welds had not been made under satisfactory metallurgical control.

On the recommendations of the association, it was decided to machine out all the original welds and to re-weld the units under careful metallurgical control. Several tests were carried out to decide on a suitable heat treatment cycle which would avoid excessive hardening in the zone adjacent to the weld and prevent cracking of the welds. The procedure finally recommended involved pre-heating the castings in a furnace before welding and returning them to the furnace immediately welding was completed so that the rate of cooling could be controlled.

All the track units from the three vehicles shipped from this country in November, 1956, together with seventy spare units, were re-welded in this way by the staff of the British Welding Research Association. There were no failures in the track units during the journey across Antarctica.



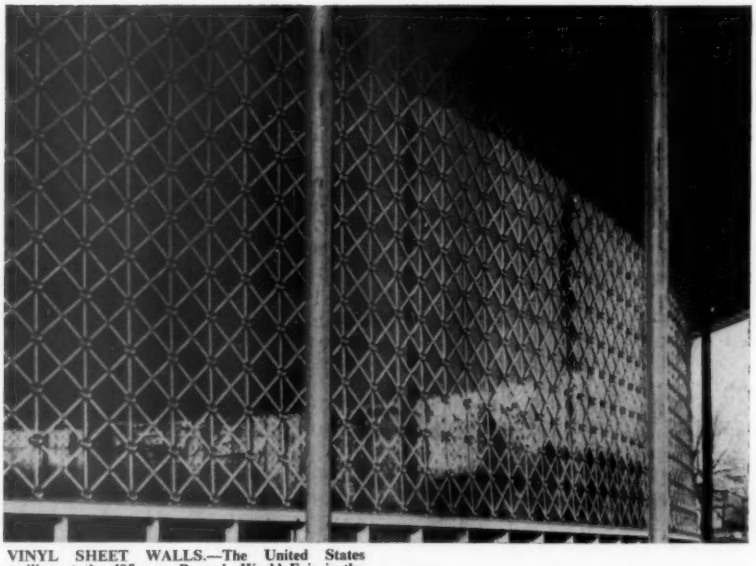
CANADIAN GIRAFFE.—This Perkins-engined machine has a 110 ft long "neck". It was designed and manufactured by Trump Limited in Oliver, British Columbia, and is now in operation in the Gaspe Copper Mines in Quebec Province. It is hydraulically operated by a Vickers vane type pump delivering 12 gpm at 1,750 psi. The machine is suitable for a wide variety of work including municipal, painting and inspection in shipyards, aircraft servicing, window and wall cleaning, billposting, installation of radio and television aeriais, and fire and rescue work.

Steel Output

The annual report for 1957 of the British Iron and Steel Federation shows that in the U.K. steel output continued to advance in 1957 when in some countries, as for example the U.S.A., it had ceased to rise or was declining. The increase over 1956 was 6% for the first nine months and 5% for the year as a whole. The increase in steel production was not, however, matched by a proportionate movement in home consumption of finished steel. In the first half of 1957 consumption was 3% below the level in the same period in 1956. From mid-summer onwards there was some recovery in consumption, reflecting, in part, the higher level of activity in the shipbuilding, motor car and durable consumer goods industries. By the end of the year, however, the general position was again uncertain. Imports of steel, which totalled 1,771,000 ingot tons in 1956, fell to 953,000 ingot tons in 1957. This reduction might have been greater but for the existence of long-term contracts which could not be cancelled at short notice. A factor which cushioned the check to home consumption was the industry's performance in increasing exports.

New Steel Plant

The report records that the principal new plant in 1957 included some 350 additional and replacement coke ovens and about 1 million tons of additional sinter capacity came into operation at Colvilles Limited (Ravenscraig) and South Durham Steel & Iron Company Limited (West Hartlepool). New blast furnaces were blown in at Dorman Long (Steel) Limited (Cleveland), Colvilles Limited (Ravenscraig) and South Durham Steel & Iron Company Limited (Cargo Fleet). The new melting shop at Ravenscraig near Glasgow, with three 200-ton open hearth furnaces, was brought



VINYL SHEET WALLS.—The United States pavilion at the 495 acre Brussels World Fair is the largest circular building of modern times. Created by architect Edward Stone, the building is 122 yd dia and 32 yd high. The outside walls are made from Union Carbide rigid vinyl sheets mounted on a steel frame and secured by decorative gold coloured screws

into production during the year and additional open hearth furnaces were completed at The Steel Company of Wales Limited, John Summers and Sons Limited, and Brown Bayley Steels Limited and in the new melting shop of Lancashire Steel Corporation Limited. A second large electric arc furnace (20 ft) was installed at Samuel Fox & Co. Limited. Good progress was made with the developments of Dorman Long (Steel) Limited, including the installation of the new universal beam mill and associated developments at the Lackenby works. The primary mill of the new beam mill came into operation towards the end of the year, and a new medium section mill, together with the replacement of a blooming mill, was completed at Cleveland. The new medium width hot strip mill of Steel Peech & Tozer came into production during the year at their Brinsworth Works. A new rod and bar mill was installed by Samuel Fox & Co. Limited. Taking into account these schemes and others likely to come into operation, capacity in 1958 should be 16 million tons of pig iron and about 23½ million ingot tons of steel.

New Balfour Research Centre

Development work for improvement in the design and operation of chemical process plant for many industries, and to widen the application, fabrication techniques, and uses of new materials of construction, is the object of the research and development centre on which work has commenced at Leven, Scotland, for the Balfour Group of Companies.

The group is an international concern with much experience of the initial development design and manufacture of chemical process plant. The new laboratories will be opened officially in spring, 1959.

The centre will also be available for demonstrating the application of existing designs of plant and process methods to clients' materials, to pioneer new processes and techniques, and to carry out work, without obligation, which would not justify the installation of special pilot plant by manufacturers themselves. Thus a confidential laboratory with semi-scale plant facilities will be available as a service; this should be particularly helpful for smaller firms.

The centre will provide training facilities in chemical engineering and a student and graduate apprenticeship scheme has already been launched in conjunction with local technical colleges to enable suitable young men and women to reach full professional status, and at the same time to receive practical training in industry.

The companies which comprise the Balfour Group already have over 1100 personnel at Leven in the existing works. The new centre is the first stage in the development of a recently purchased 25 acre site which will ultimately contain further fabrication shops and offices.

There will be a main pilot plant bay 160 ft long, 45 ft wide, 30 ft to the eaves, with a tower giving a headroom of 40 ft, but capable of expanding to 56 ft. A separate pilot plant laboratory will deal with size reduction, with special reference to dust problems and there will be an isolated laboratory for work with inflammable solvents and noxious gases where, for instance, radioactive material can be dealt with in comparative safety. In addition, there will be metallurgical laboratories, dark rooms, and laboratories for corrosion, physical chemistry, general analysis, chemical development, and ceramic chemistry.

The pilot plant bays will house a complete range of unit operation equipment including heat exchangers, evaporators, distillation columns, high vacuum and molecular stills, vacuum dryers, spray dryers, prebreakers, size reduction units and so on.

The services to be provided include steam at 50–300 psi, water, compressed air, power, and vacuum. In addition to this, there will be a variety of "pots and pans", filters, pumps, screens, instruments, and other plant.

Transductors and Magnetic Amplifiers

The magnetic amplifier, based on the transductor or saturable reactor, is a robust device which can function as a d.c. or a.c. amplifier, d.c. or a.c. converter, and may be used with, or instead of, relays and electronic valves for many purposes. Progress in their construction has been promoted by the development of improved magnetic materials.
Transductors and magnetic amplifiers are used in many present-day control systems. The operating principles of several circuits are described here

AMPLIFIERS are used in many control circuits so that a comparatively small current or currents can control a much higher current. There are various types of amplifiers such as a relay or contactor, thermionic valve, rotary amplifier (amplidyne, metadyne, etc.). The magnetic amplifier is a fairly recent arrangement of saturable reactors, or transductors, and other elements which may be used for the amplification, control or measurement of electrical quantities.

A.C. magnetization of a reactor

Fig. 1 shows the magnetization curve for a transformer or reactor core. For moderate values the magnetic flux density is almost proportional to the magnetizing turns, i.e. proportional to the ampere-turns in the exciting winding or to the current through the exciting winding. However, a saturable reactor is designed to operate well into the non-linear portion of the magnetization curve, as represented by the flux density O-R in Fig. 1, where the saturation effect reduces the ratio B/H and the permeability of the core.

When a ferro-magnetic core is magnetized only slightly by passing magnetizing current round a coil on the core, the magnetism disappears when the current is switched off. If the magnetizing current is increased

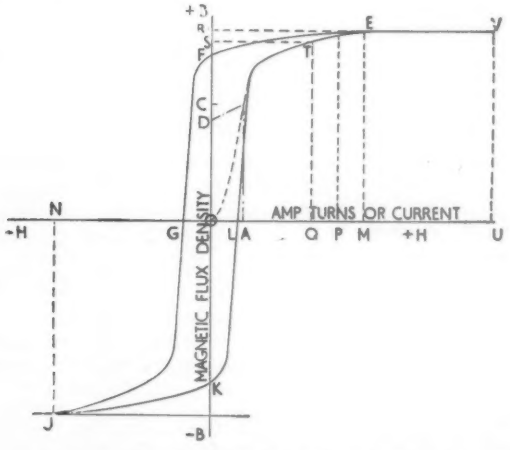


Fig. 1. Magnetization curve and hysteresis loop of a ferro-magnetic material

to the value O-A a certain amount of magnetism, as represented by the value O-D, will be retained in the core when the current is reduced to zero. If the magnetizing current is increased to a greater value, such as O-M, a greater amount of magnetism, such as O-F, will be retained when the current is reduced to zero. After increasing the magnetizing current to the value O-M and then reducing the current to zero, a reverse current O-G must be passed through the coil to reduce the core magnetism to zero. On increasing the reverse current to the value O-N the magnetic flux density will rise to the value N-J of reverse polarity.

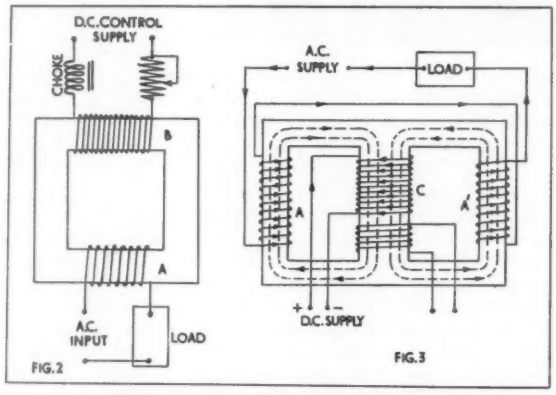


Fig. 2. Arrangement of a simple saturable reactor
Fig. 3. A common arrangement of a transductor or saturable reactor

When the current is reduced to zero and again increased to the value O-M the flux density will pass through the points K and L to E again.

Due to the lag of the magnetism behind the magnetizing amp-turns or current the B/H curve obtained during a complete cycle of a.c. magnetization forms the closed loop of L-E-F-G-J-K-L, when the peak currents are O-M and O-N. This lag is due to hysteresis in the core material; this effect may be likened to a form of magnetic friction, and causes heating of the core and loss of power. The hysteresis loss per cycle is proportional to the area of this hysteresis loop, and depends on the maximum flux density and the hysteresis coefficient. The latter depends on the type of core iron used.

Fig. 2 shows the arrangement of a simple saturable reactor or transductor having a coil A through which a load is fed from the a.c. supply. When no current is passed through the second coil B the core is magnetized solely by the a.c. load current. This creates a self-induced a.c. voltage in the output coil A, of value proportional to the number of coil turns, and to the rate of change of the flux linked with the coil. Provided the

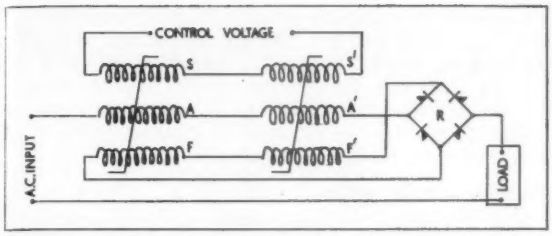


Fig. 4. Schematic diagram of a magnetic amplifier with self-excitation (feedback)

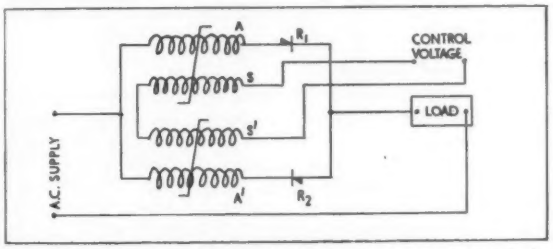


Fig. 5. Schematic diagram of a magnetic amplifier having automatic excitation

peak value of the flux is not sufficient to create a saturation effect in the core the virtual value of the self-induced voltage will be proportional to the number of coil turns, the frequency of the a.c. supply, the form factor of the current, and the difference between the positive and negative values of the peak flux. This self-induced voltage will reduce the voltage applied to the load and thus reduce the load current.

Effect of core saturation

If an a.c. current varying between the limits O-A and O-G in Fig. 1 is passed through the coil A, and at the same time a constant uni-directional current O-P is passed through the coil B, the total amp-turns acting on the core will vary between the limits Q and M; P-Q being equal to O-G, and P-M equal to O-A. As a result the flux density will merely vary between the limits O-R and O-S, and hysteresis loop will be a thin loop between E and T. The self-induced voltage in the output coil A will then depend only on the difference between the flux densities R and S and will be very low. The coil A will offer little impedance to the load current so the latter will have a comparatively high value. Thus the load current can be varied by simply varying the value of the d.c. current through the coil B.

A common arrangement of a transductor is shown in Fig. 3. The output windings consist of two coils A and A′ on the outer limbs of the core, these coils being connected in series. With no d.c. current, or only a small current, through the coil C the magnetic flux created by the load current through A and A′ passes through the centre limb of the core, as indicated by the dotted lines. When d.c. current is passed through the coil C this creates flux which passes through the outer limbs of the core and linked with the output coils. If the d.c. current is sufficiently high the centre limb becomes saturated with magnetism so that the current through the coils A and A′ can pass no flux through the centre limb. Since the coils A and A′ act in opposition round the outer limbs they can pass no a.c. flux through the core. The core flux linked with coils A and A′ then has practically a constant value and maximum a.c. load current passes.

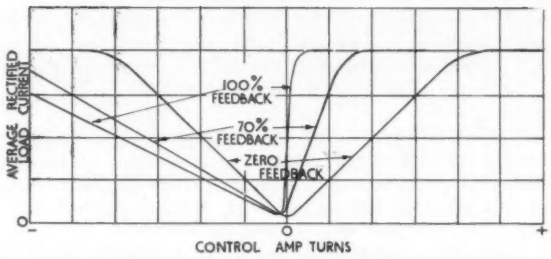


Fig. 6. Effect of feedback on a series-connected self-excited magnetic amplifier

If the impedance of the load circuit is constant and the wave form of the a.c. voltage is sinusoidal, the wave form of the load current will also be sinusoidal. With reduced value of d.c. current through the coil C an a.c. flux is superimposed on the constant flux and the load current is reduced. The a.c. flux then induces a self-induced a.c. voltage in the coils A and A′ with which the flux is linked. If the impedance of the control circuit of C is low this a.c. flux may cause fluctuation of the control current when this has a low value. However, these fluctuations can be reduced by connecting a choke coil in the control circuit, as indicated in Fig. 2.

Various arrangements of reactors

The saturable reactor or transductor can similarly be used to control the value of a d.c. load current obtained by rectifying the a.c. output. In order to saturate the core of a simple transductor a comparatively large number of amp-turns are required. However, they can be used as magnetic amplifiers by the use of additional windings on the core. The main windings on the magnetic amplifier are the output windings through which power is delivered to the load. The output windings may include, as a separate winding, the power winding to which power is applied from the a.c. supply, although the functions of the power windings are usually included in the single output winding.

The control windings may comprise signal windings, feedback and bias windings. The signal winding is a control winding through which the control signal current is passed. The feedback windings are control windings through which may be passed a current which is a function of the output quantity of the amplifier. A bias winding may be included on the core, current being passed through this winding to bring the flux density within a particular operating range required.

Fig. 4 indicates the arrangement of a magnetic amplifier having output windings A and A′, control or signal windings S and S′, together with feedback windings F and F′. It will be noted that the a.c. output current passes through the full-wave bridge-connected rectifier R; the a.c. volt drop across this unit is rectified and applied to the feedback windings F and F′ so that the output is, to some extent, self regulating. By this means the ratio of output current variation to variation of signal current can be greatly increased. In some cases a magnetic amplifier may have 100 per cent self-excitation, the number of turns on the feedback winding being equal to the number of turns on the output winding.

The arrangement indicated in Fig. 5 constitutes a self-saturating, or self-saturated, magnetic amplifier, sometimes called an amplistat or magnestat. The feature

of this arrangement is that half-wave rectifiers R_1 and R_2 are connected in series with the output windings A and A′, so that current passes through the windings A and A′ during opposite half cycles of the a.c. supply and output.

Fig. 6 shows the effect of feedback in a series-connected self-excited magnetic amplifier. It will be seen that the amplification factor, which is proportional to the slope of the curves with positive control amp-turns, is increased with increased feedback.

Saturable reactors and magnetic amplifiers have no wearable parts and are of robust construction. Unlike an electronic amplifier they have no filaments requiring heating, and are therefore operative immediately they are switched on. They have many uses. A saturable reactor may be used in conjunction with electronic valves used to feed the control circuit; in this way a considerable power can be controlled by means of a small rheostat. Since the load circuit is controlled by means of reactance the efficiency of the control system is high, although the power factor of the load circuit is low on reduced load. A saturable reactor may be used to provide continuously variable control of an electric furnace. In this application switches may be used for separate sections of the heater, with a saturable reactor connected in series with one or more sections.

Battery charging control

A battery may be maintained in the correct state of charge by feeding the battery through a saturable reactor and rectifier from a.c. mains. Fig. 7 shows a battery charging circuit in which load compensation is provided by means of a saturable reactor. The primary current of the transformer passes through the windings A and A′ of the reactor and the charging current can be adjusted by variation of the d.c. bias current through the windings B and B′. The battery voltage is applied to the load circuit through the control windings C and C′. In this way the voltage applied to the primary windings of the transformer can be arranged to increase automatically and so increase the charging current on increased load on the battery.

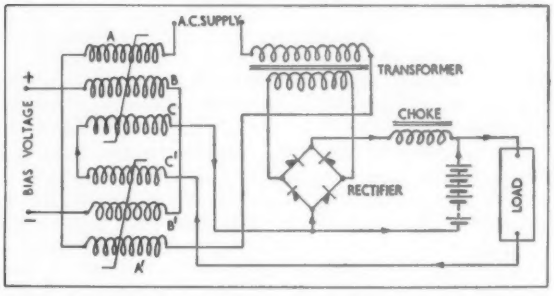


Fig. 7. Schematic diagram of a battery charger with load current compensation

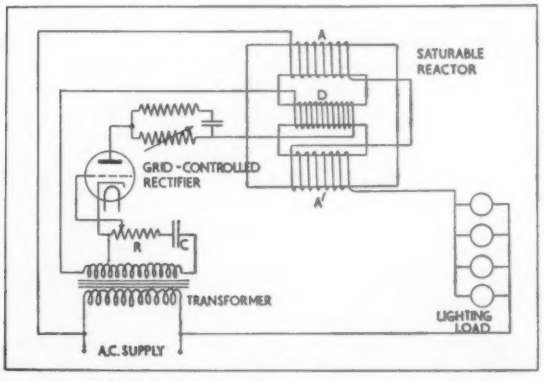


Fig. 8. One method of using a saturable reactor to control an a.c. lighting circuit

Lighting circuit control

Fig. 8 shows a lighting control circuit in which the current through the control winding D of the saturable reactor is obtained from a grid-controlled rectifier, the output of which is controlled by means of the variable resistor R.

Motor speed control

Fig. 9 shows how a saturable reactor may be used to control a variable-speed d.c. motor fed from a single-phase a.c. supply. The circuit provides infinite control of the motor speed over a ratio of about 15 to 1 and is suitable for a motor up to about 2 hp. If required a remote potentiometer may be used for speed control. The motor field windings are fed through the full-wave metal rectifier unit R_2 from the secondary windings of the transformer. The control potentiometer is also fed from R_2. The signal winding S on the saturable reactor is fed from the rectifier R_2 through the motor armature, the switch S, resistor R and the potentiometer. The motor speed can be controlled by adjustment of the position of the moving contact T on the potentiometer. The main rectifier R_1 is fed from the a.c. supply through the output windings A and A′ of the reactor when the switch S is closed; the rectifier R_1 supplies the motor armature through the feedback winding F.

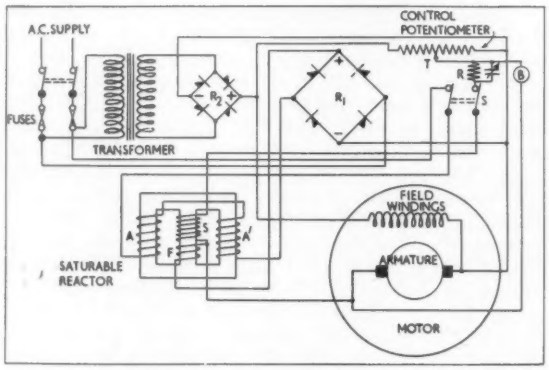


Fig. 9. Variable-speed motor control unit with transductor

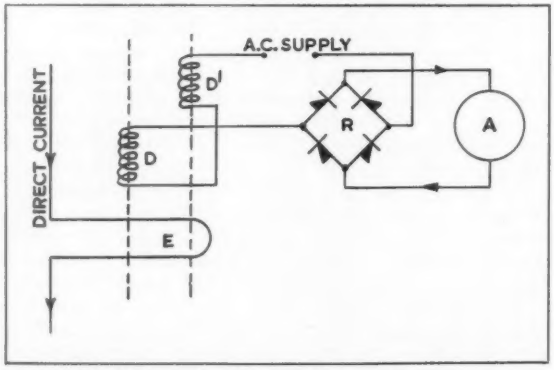


Fig. 10. Use of a transductor as a d.c. current transformer

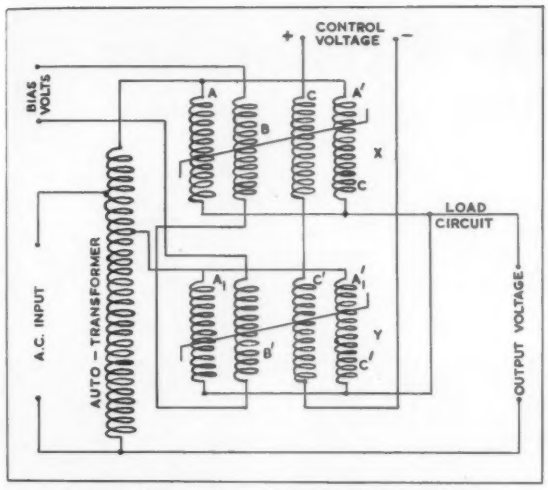


Fig. 11. Schematic diagram of an a.c. line voltage regulator

On a given load and armature current I_A the motor speed is proportional to the back e.m.f. E_A generated in the armature windings, with a given field current. The value of E_A is equal to $V_A - I_A R_A$, where V_A is the voltage applied to the armature, and R_A the resistance of the armature. Should the load on the motor increase, the motor will tend to slow down slightly, thus reducing the back e.m.f., E_A, which is proportional to the product of motor speed and the magnetic field flux. This causes some increase of the armature current I_A, which is equal to $(V_A - E_A)/R_A$. As a result the feedback current through F is increased to raise the d.c. amp-turns acting in the reactor. The flux variation is thus reduced in the reactor to reduce the volt drop across the windings A and A′, so that the a.c. voltage applied to the rectifier R_1 is increased to raise the voltage V_A applied to the motor armature. In this way the motor speed is restored to the required value. The relay B protects the ballast resistor R in the event of violent change of speed being demanded, whilst a static current-limiting device can be incorporated so that the motor can be switched on with the potentiometer set for any required speed.

D.C. current or voltage transformer

It is usually inadvisable in a high-voltage d.c. circuit to connect an ammeter directly in the main circuit. It is, however, possible to supply a moving-coil d.c. ammeter A from a secondary circuit in which a rectifier unit R is fed through coils D and D′ on a transductor connected to a subsidiary a.c. supply as in Fig. 10. The coils D and D′ are toroidally wound on strip cores so that the magnetization current is low, a busbar type coil E being connected in the d.c. circuit. Variation of the d.c. current then alters the flux density limits in the transductor, and this is reflected in a changed voltage applied to the rectifier and corresponding change in the ammeter reading. The system can be used to supply a voltmeter connected across a resistor in place of the ammeter A.

A.C. voltage regulation

Voltage regulation of an a.c. supply can be obtained by using an auto-transformer in conjunction with two saturable reactors X and Y as in Fig. 11. With maximum positive control d.c. current passing through the winding C and C′, the transductor X is saturated and thus has a low impedance, whilst transductor Y has a high impedance to the a.c. load current through the output windings A_1 and A_1'. Under these conditions most of the a.c. load current will pass largely through the windings A and A′ from the high-voltage tapping on the auto-transformer. With the maximum negative value of control current through the windings C and C′, the transductor Y is saturated, whilst X has a high impedance; the a.c. load current then passes largely through the windings A_1 and A_1' from the low-voltage tapping on the auto-transformer. Thus the output voltage can be controlled continuously between the maximum and minimum values provided by the auto-transformer. This control circuit can be used in an automatic voltage regulator to maintain the output voltage within plus or minus 1·5%. There is slight distortion of the wave form of the the output voltage, but this is less than in the case of a simple series saturable reactor.

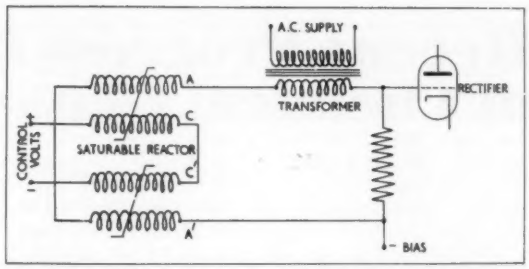


Fig. 12. Schematic diagram of circuit used to control the firing of a rectifier

Control of the firing point of a rectifier

Grid-controlled rectifiers are commonly used to control the speed of a d.c. motor, and for other purposes. One method of controlling the output of the rectifier is by using a saturable reactor to control the phase of an a.c. voltage applied to the grid of the rectifier. The most precise control is obtained when this grid voltage is applied in a rapidly rising pulse. Fig. 12 shows a circuit which may be used for this purpose. The a.c. primary voltage of the transformer is sufficient to saturate the core during the greater part of each half cycle of the a.c. supply. As the current reverses twice in each cycle, the flux changes rapidly from saturation value in one direction to saturation value in the opposite direction. The phase of the output voltage pusles can be controlled by d.c. current passed through the windings C and C′.

Tool Steel for Abrasives

A combination of high hardness, red hardness, abrasion resistance and a good measure of toughness are claimed as a result of extensive tests conducted by Samuel Osborn and Company Limitel, Clyde Steel Works, Sheffield 3, for their new Mushet Special V.G. high speed steel. The material is a specially balanced tungsten-molybdenum super high-speed steel, containing cobalt for enhanced red hardness with greatly increased carbon and vanadium contents to employ to maximum effect the great intrinsic hardness of vanadium carbide.

Suitable for all types of cutting operations it is particularly recommended for cutting abrasive materials, and those of high work hardening capacity.

Recent Progress in the Production of Chemical Glassware

During the past few years engineering methods which have long been established for the handling of metals have been applied to glass, with a resultant increase in output. In a previous issue (MECHANICAL WORLD, March 4 1949) advances in the industry up to that time were discussed. Here progress in the production of British chemical glassware is reviewed.

LITTLE more than 40 years ago Britain was in a very backward position with regard to chemical glassware. Up to 1914 the bulk of laboratory glassware came from Germany. Even with that supply cut off by war conditions, it was quite a few years before Britain could manufacture a test tube or a beaker comparable in quality with the foreign products. Gradually, however, the problems involved in fabricating such goods were solved, and as there are only a few chemical substances that cannot be handled in glass, it was natural that glass manufacturers' thoughts turned to the production of larger sizes of glassware, having the same good properties as laboratory glassware, but with capacities sufficient to handle industrial processes. With the development of these larger sizes the problems that often confronted those in charge of new chemical processes, the transfer of the process from the glass of the laboratory to the metal plant of the works, were solved.

The development of chemical glassware manufacture in Britain proceeded only very slowly for some years after the first world war, and it is only during the past 20 years that there has been somewhat of a revolution in this field. It was in 1934 that Triplex Safety Glass Company Limited realized that the methods adopted in the manufacture of glassware were those of the glass-blower rather than those of the engineer. In particular there was needed a range of standardized ground-glass joints for laboratory glassware, so that assembly of chemical apparatus would be a matter of minutes rather than hours, as was often the case with cumbersome arrays of corks, glass tubing, flasks and rubber tubing then forming the standard auxiliary equipment of the laboratory. At that time there was a mere £10,000 yearly turnover in this type of glassware in Britain, while there were considerable imports from Germany, so that the idea of expanding the British output was not very attractive to business men. Nevertheless, at the end of 1934, a new company, Quickfit & Quartz Limited, was formed; "quickfit" denoting the type of material that was to be manufactured, and it was intended at that time to manufacture quartz articles as well. Against the forecast of a possible turnover of £10,000, shared with German competitors, Q. & Q. has now reached a turnover of nearly £750,000, with profitable exports to Germany and elsewhere.

Expansion

In 1953, extensions totalling some 25,000 sq ft were completed at Stone, Staffordshire, including a new shop for the fabrication of industrial plant in glass. The occupation of the new building made possible the re-organization of other sections of the factory, resulting in greatly increased production. The development and research department and the laboratories now occupy separate premises. An independent unit has been established for the production of special apparatus and equipment to customers' specifications. This department is engaged on unusual work which cannot conveniently be dealt with in routine production. Men engaged on this type of work function as a team instead of being accommodated in different sections throughout the factory. In order to deal with the steadily increasing volume of production, a development and marketing company for industrial plant, Q.V.F. Limited (quickfit visible flow) was formed jointly by Q & Q. Limited and James A. Jobling & Co. Limited the well-known makers of glass pipelines. The aim was to pool resources so that new openings might be more quickly and economically developed.

Fig. 1. One of the two conveyors which carry the work of four lines of benchworkers

Electric welding

At the Stone factory a plant for the electric welding of glass has been installed. The advantages of electric heating are its ability to heat glass rapidly and locally, and to manufacture articles in thick glass which were either extremely difficult or even impossible to obtain by other existing methods. Heating glass by electricity is based upon the fact that, above a certain temperature, borosilicate glass becomes a conductor of electricity, so that electrical energy can be absorbed. The resulting

Fig. 2. Inspection department adjacent to the joint-forming shop

heat formation rapidly raises the temperature to the point where the glass is fluid and can be worked and blown in the conventional manner. A striking advantage of this process is in the heating of thick-wall section material. With the customary oxy-coal gas heating, glass being a poor conductor of heat, it can be extremely difficult to transmit heat from the outside of a tube to the inside. With the electric heating method, the electrical energy is absorbed in depth and does not depend on heat conduction to raise the temperature of the glass throughout. Another point in favour of electric heating is that the zone of application can be kept to a minimum. The normal large and powerful oxy-coal gas flames spread heat over a wide area, whereas the electric method permits localization; a useful feature when manufacturing intricate articles.

Much of the routine production is, however, still carried out with the aid of coal gas, and on opening the factory at Stone the gas supply presented a problem. The town of Stone could offer only 600 cu ft per hr, whereas the factory's requirements were in the region of 6000 cu ft, but the problem was solved by installing an 8 in. gas main from Stafford, 8 miles away.

Tooling up

Much of the manufacturing equipment at Stone has been built to the company's own design. Examples are the shaping lathes used in the production of conical ground-glass joints; special burners for certain jobs, which eliminate the excessive noise of the ordinary nozzle-burner; and the very heavy lathes with adjustable speeds, adjustable headstock spindles, and compressed air fed through the lathe head, which are used for the production of industrial plant.

Laboratory glassware production is carried out in three main shops—joint-forming, grinding and lamp-working. As a start to increase output, an entirely new mechanized layout has recently been installed in the joint-forming and grinding shops. A conveyor system, Fig. 1, from a battery of 48 lathes takes products direct off the machines for the next stages of production, inspection (Fig. 2), annealing and grinding. Most of the grinding is done on new semi-automatic machines (Fig. 3) which have been designed by the company's development department. These grinding machines increase productivity to between four and five times when compared with the hand-grinding method, although the latter process is still used for small runs.

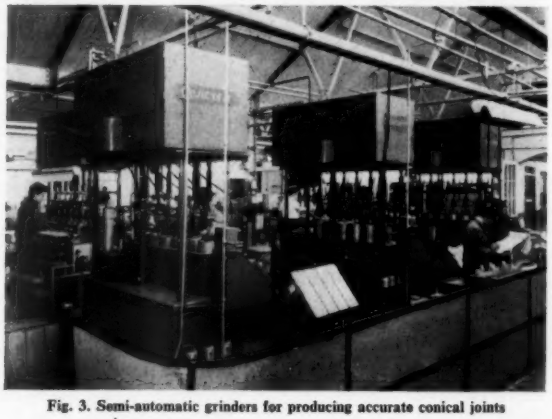


Fig. 3. Semi-automatic grinders for producing accurate conical joints

Under the semi-automatic method a very high standard of quality is obtained, the conical joints having profile accuracies to within 0·1 mil.

It is often necessary to improve the accuracy of dimensions of glass articles after lampworking. Lengths may require adjustment, faces of flanges may need to be made true, etc. Glass can be ground by abrasive grain, fabricated abrasive grinding wheels, and diamond crystals. Flat, spherical and tapered surfaces are ground and lapped to high precision by the use of abrasive powders of varying coarseness, with finishing-off laps of softer materials such as copper or cast iron. These laps load-up with the abrasive powder and so can remove glass by the lapping process used by engineers and gauge makers. The introduction of the high productivity grinding machines has been effected without any substantial reduction in the labour force; for the higher output has enabled new markets, particularly overseas, to be exploited.

Annealing plant

Another recent development leading to greater efficiency embodies the use of special types of annealing plant. Previous to this, intermediate annealing had been carried out by heated cowls which could be dropped over and lifted off the glassware. This principle is known as the "top-hat" method and has now been applied to the final annealing of heavy-wall goods which cannot be properly annealed in a continuous lehr or annealing tunnel. Working in conjunction with the Midlands Electricity Board and Shelley Electric Furnaces Limited, an electrically-heated oven has been designed which can be raised and lowered on a travelling hoist (Fig. 4). This oven has overall dimensions of approximately 12 ft by 6 ft by 6 ft, and weighs 3 tons. It can readily be lowered over a new batch of glassware while completed pieces cool. Also, while one batch of glass is being annealed, another can be prepared. Immediately the first batch is finished, the

Fig. 4. The Shelley oven gives improved and quick annealing of heavy glassware

second can begin, thus giving a considerable increase in throughput as well as a saving of heat.

Production in the factory is divided into two main streams—laboratory glassware and chemical plant. The difference from the manufacturing point of view is that glass plant is made in much larger sizes, but smaller numbers. The raw materials are glass tubing of appropriate diameters, and mouldings of comparatively simple shapes, but of many sizes. These are joined together and reformed into the various units, many of them very complicated. This work is carried out by lampworkers using in most cases lathes or specialized jigs. Where small quantities of light work are required—and a large amount of scientific glassware is of this nature—the deft hands of the skilled bench workers are much in evidence. Even in the chemical plant shop, where most of the product is too heavy for handwork, there is an important section of benchworkers bending and assembling the coils that are later built into heat exchangers. It is in this workshop that the large oxy-coal gas flames needed to work the thick glass are supplemented by electric heating. Two-stage annealing is generally necessary with heavy-walled glassware.

Laboratory glassware

Laboratory glassware with interchangeable conical ground-glass joints is produced from glass tubing and glass mouldings. The cones and socket blanks are preformed on lengths of tubing or on flasks, inspected and annealed before the grinding operations which produce the final accurate taper which ensures gas- and liquid-tight seals. After final inspection, the finished interchangeable joints are either sent to the stores for direct sale, or re-issued to the scientific lampworkers for assembly into the various units. Care in production and inspection at all stages is vital for the production of quality laboratory glassware—inspection for accurate size and fit of joints; inspection of blownware for conformity to standard, for appearance, for freedom from strain, from pinholes, and other defects. This class of product is produced from blown mouldings and glass tubing, hand- or machine-drawn, by scientific lampworkers, working at a bench using an air-coal gas or oxy-coal gas flame. The glass tubing is rotated in the flame by the lampworker and the articles produced by bending, forming, fusing and mouth-blowing of the hot glass, according to requirements. Bench lampworking is a free-hand process, the only tools being tweezers, shaped carbons, reamers, etc., and in some instances moulds.

Fig. 5. Chemical glassware leaving the annealing lehr after treatment

The maximum size of an article capable of being produced by this technique is governed by the size of tubing the operator can rotate in his hands, and the weight he can hold without undue fatigue. Articles of 2 in. dia are generally about the largest a lampworker can handle. During lampworking some part of the glass article is being heated above its softening point, and rapidly cooled from time to time; while other parts remain cold, glass being a poor conductor of heat. As a consequence, lampblown articles, when completed, are always under unequally strained conditions. These strains could be of sufficient magnitude to cause fracture of the article in subsequent service, or even during cooling down after manufacture. A skilled lampworker should, therefore, during manipulation, ensure that the strains are not sufficiently great to cause fracture on cooling. However, a further process, annealing, is necessary to remove these strains to prevent risk of fracture of the article during normal service. These strains can be removed or reduced to unimportant proportions by raising the temperature uniformly until the glass is slightly soft, and then allowing the whole to cool slowly at a controlled rate. This process is carried out in an annealing kiln or lehr (Fig. 5). The lehr is a partially closed chamber heated by gas or electricity, the internal temperature of which is capable of being raised and lowered in prescribed times. To allow of continuous operation the lehr is arranged in the form of a tunnel, the glassware entering at one end and leaving at the other; various zones in the tunnel are maintained at specific temperatures, accomplished by varying the quantity of heating element in the different areas. The parcels of work are contained in wire trays and their conveyance through the lehr is by a wire mesh belt operated by a variable-speed geared motor under the bench. Fluctuations of temperature within the lehr can be compensated to some extent by varying the speed of the conveyor; but temperatures tend to remain steady by the use of a small asbestos cloth curtain at the two ends of the tunnel. The curtains also prevent draughts from disturbing the temperature gradients, for draughts would chill the glass and reintroduce strain.

The transparency of glass enables these strains to be viewed by their effect on polarized light. For this

purpose a polariscope is used and the operating principle is based on the double refraction of glass when in a strained condition. These instruments enable the inspectors to view the article against a purple illuminated background. An unstrained part appears the same colour as the general background, while strained parts reveal themselves in patterns of colours, reds, yellows, blues, etc. From experience and comparison with standard strain discs the effectiveness of annealing can be judged.

Chemical plant

For rather more than a decade glass chemical plant has been in use and it is particularly attractive to the chemical, food and allied industries, where problems of corrosion and/or cleanliness arise. Glass plant is often employed in conjunction with metal plant such as stainless steel and other corrosion-resisting equipment. To connect glass to metal pipe flanges, it is merely necessary to make metal backing flanges for glass pipe or other glass unit, the metal flange being drilled with the required number of holes to the pitch circle of the flanges on the metal vessel or pipe. Where weight of equipment is a consideration, the glass units of plant have an advantage in that they weigh much less than their metal counterparts with same capacity. As an example which occurred recently, one plant using glass pipeline weighs 2½ tons, but with metal pipelines of similar capacity, the equipment would have weighed 21½ tons, in addition to the extra weight of the framework to carry it. Since the glass chemical plant resembles in properties ordinary laboratory glassware, it is immune from the physical shocks of alternate heat and cold. The linear coefficient expansion of glass pipeline is very low and this feature, allied to its physical capacities, permits of the safe passage of hot or very cold liquids. Glass plant and pipelines can be cleared with steam after use, while most of such equipment will withstand internal pressures of 600 psi before bursting.

The world's largest glass waste-line installation, incorporating over a mile of glass piping, has recently been supplied to the new Nottingham College of Technology. The entire installation is completely sealed and has no open traps. Beginning on the seventh floor of the building, it forms one continuous system to the outside drains. The main stacks consist of lines of 4 in. bore, with 3 in., 2 in., and 1½ in. bore lines at intermediate stages. The whole installation is fitted within ducts through the walls, and the horizontal lines are carried in the cavities between ceilings and floors. There are 284 sink units, each with its own glass sink trap. Any build-up of solids can be detected at once, and the trap can be opened by hand and cleared. Several systems are used to trap the effluent from the sinks, employing either individual traps for each sink, or traps serving several sinks simultaneously. In waste pipelines from chemical laboratories the choice of materials is limited to those having high resistance to chemical attack, and it was considered that glass provided the best answer. Not only does the smooth surface tend to keep the lines clean, but any stoppage can be quickly found because it is visible. For such pipelines the traditional lead piping would not be suitable, for lead is vulnerable to some chemicals. An alternative to glass is stoneware with corrosion-resisting joints, and in specific applications it is the cost which is usually the deciding factor.

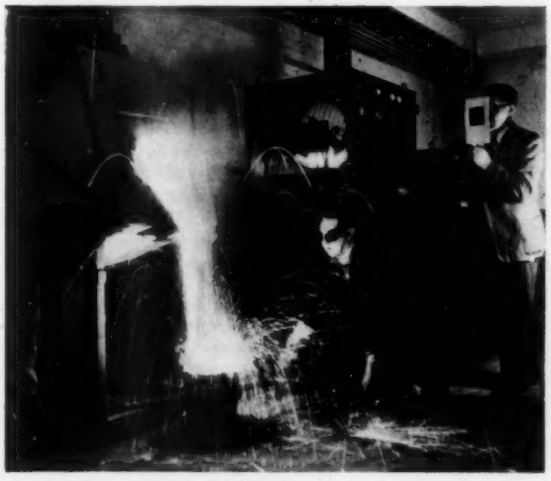
Based on experience within the past decade, there is no doubt that these special types of glassware in industry perform a useful function in their particular sphere, but the great majority of plant units and equipment will still be made in metal. The latter is mechanically stronger, easier to machine, can stand up without special supports; while if a fitter drops a pipe he can still pick it up in one piece.

H.F. Coreless Induction Furnace Employs Mercury-arc Converter

With a view to reducing the high capital outlay involved with the installation of high frequency coreless induction furnace plant Metalectric Furnaces Limited, Smethwick, and Hackbridge & Hewittic Electric Company Limited, Walton-on-Thames, have developed a coreless h.f. melting unit which obtains the requisite frequency conversion by using glass bulb mercury arc rectifiers. This new furnace is about the same in capital cost as mains frequency plant, without the additional expense of a motor alternator for the frequency conversion. No special foundations are needed for this equipment since the only moving parts are the small cooling fans for the rectifier bulbs. Other advantages are the higher conversion efficiency of the mercury rectifier as against that of a motor alternator and the elimination of capacitor switching since changes in the load during the melting are reflected in the generator and cause automatic adjustments of the frequency. Constant use causes no alteration of conditions within the bulb, which is entirely pumpless and capable of withstanding heavy overloads without damage.

Control and metering is arranged on the front panel of the convertor cubicle. Operation of the furnace is very simple with pushbutton control to close the circuit breaker connecting the equipment to the three phase supply and again to switch on the h.f. current. Power input is adjusted by a simple control knob.

The new equipment is fully developed for ratings up to 100 kW, and is suitable for all ferrous and non-ferrous metal. Sizes above 100 kW are in advanced stage of development.



Metalectric—Hewittic 50 kW induction furnace, 120 lb capacity, pouring mild steel at the works of Metalectric Furnaces Limited

Milling Titanium Alloys

Some practical results from a basic study

SHOULD high speed steel, cast alloy, or carbide be used for milling titanium alloys? Although no completely satisfactory answer has, as yet, been found to this controversial question, research engineers of The Glenn L. Martin Company in the United States have made strides toward overcoming many of the present problems. Studies have been made of the existing milling difficulties, and a programme aimed at solving as many of these problems as possible has produced a great deal of information.

As reported by A. L. Winkler, senior manufacturing engineer to the company, in the initial study, several machining operations, such as facing, profiling and slotting, were performed on a quantity of AMS 4925 titanium forgings, 36 in. long (Fig. 1). Attempts were

Fig. 1. Sketch of part made from titanium forging. Length varied from 24 to 36 in

made to perform the facing operations by using varying combinations of carbide grades, rake angles, feeds and speeds. Since the welding of chips to the cutting edges could not be overcome and since tool life was extremely short, the results were unsatisfactory.

The facing operation on this initial quantity was finally completed with high speed steel face mills operating at a speed of 40 to 50 sfm and a feed of 0·750 ipm. Production, however, was low, and regrinding of cutters was necessary after several passes. Part warpage, moreover, was often in excess of $\frac{1}{16}$ in.

On the second lot of parts, carbide slab mills were used for the facing operation. The cutters, which were of grade C-2 carbide and 30° and 45° helix angles, had originally been designed for cutting aluminium. These were mounted on a horizontal miller with two arbor supports used to provide added rigidity. Conventional cutting was required to insure limited contact between the tooth face and the forging scale.

The best results were realized at 120 sfm and at 3 ipm feed with a liberal flow of sulphur base oil. The helical spiral of the cutting teeth caused the chips to slide along the cutting edges at a sufficient rate to prevent the chips from welding to the cutting edges. The r.m.s. finishes were superior to those obtained using facing mills, and part warpage was practically eliminated. The 30° and 45° spiral blades cut equally as well, although the 45° spiral produced the better finishes. Tool life was excellent and, in some cases,

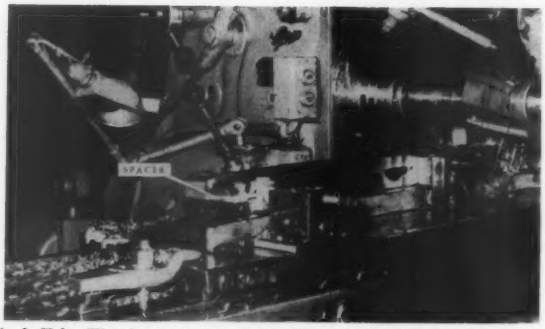


Fig. 2. Slab milling the part to size, showing the spacer inserted to prevent the slot from closing

cutters were used for two eight-hour shifts before regrinding was required.

These parts were then faced to size by climb cutting with slab mill cutters. It was observed, however, that during this operation the slot, which had been previously milled was closing. Support necessarily had to be given it before proceeding with the cutting (Fig. 2).

The profile milling of the parts shown in Fig 1 was performed on Hydro-Tel machines. Initial cuts were made with high speed end mills. A lack of rigidity in the set-up, however, caused the parts to flex sufficiently for them to move to and from the cutter. This difficulty was overcome by providing back-up blocks and clamps spaced 8 in. apart (Fig. 3). Tool life was still limited to several passes, and 1·500 ipm was the maximum feed rate. When helical carbide end mills were used, feed rates were increased up to 3 ipm, with tool life, in some instances, greater than an eight-hour shift performance.

To prevent grab and breakage, the cutters were fed gradually into the cut. If the chips were allowed to gather and be carried back through the cut, the gradual chipping of the cutting edges occurred. In several trials, the side of a $\frac{3}{4}$-in. dia carbide end mill was used for profiling the side of a $\frac{3}{4}$-in. deep slot. However, an excessive flexing of the shank occurred and the entire end of the mill broke off just above the carbide flute. Plunge cutting with carbide was avoided, as this approach was determined to be a contributing factor in tool breakage. It was most important that the operator maintain a close check on the condition of the end mill as initial wear begins slowly but increases rapidly.

To evaluate the effects of two types of coolant on carbide end mills, a force flow of sulphur base oil was used on one machine, while a water-soluble oil, applied in a spray mist form, was used on another machine. There was no apparent difference as a result of the two coolants. In the free flow application, however, the

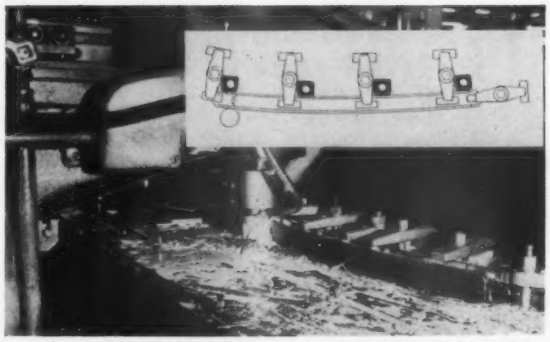


Fig. 3. Profile milling. The insert shows a top view of the back-up blocks and clamps provided to minimize flexibility

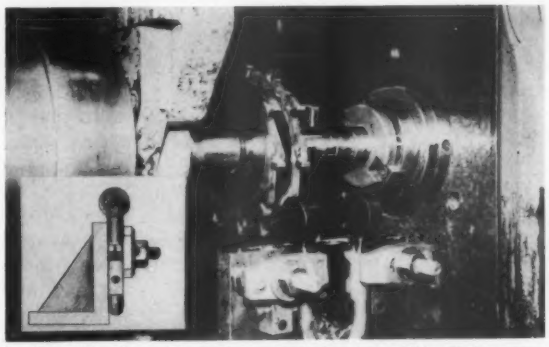


Fig. 4. Straddle milling of the two legs on the U-shaped part. Although the construction of the original tool appeared to be satisfactory (see insert detail), it lacked the required rigidity for the milling operation

operator had to continually brush away the collection of chips, while the pressure of the spray mist carried the chips away from the cutter. Carbide grades were difficult to evaluate since both C-2 and C-6 grades appeared to perform equally as well.

The part shown in Fig. 1 was slotted with cast alloy cutters since previous results using high speed steel and carbide slotting cutters had not been satisfactory. The initial plans were to perform this operation on a stub arbor. However, since all previous tests had demonstrated the necessity for rigidity, the tools were designed for maximum support, and a slotting cutter, with two arbor supports and a flywheel, was used. Feed rates were less than 0·750 ipm and tool life between regrinds was extremely limited. Since it was impossible to eliminate the tendency of chips to weld to the cutting edges, a wire brush, mounted on the overarm support, was employed to remove the chips and prevent their carry-through on succeeding cuts.

The pressure of the slotting cutter forced the sides of the part being machined outwards, causing an expansion of the slot being cut. The addition of support blocks to the fixture corrected this condition. While much was learned from these tests, more development is needed to perfect the slotting operation.

One titanium alloy detail required the straddle milling of two legs of a U-shaped part. The original fixture was designed to support the part in an upright position (Fig. 4). This set-up allowed an excessive flexing of both the part and the fixture during machining, resulting

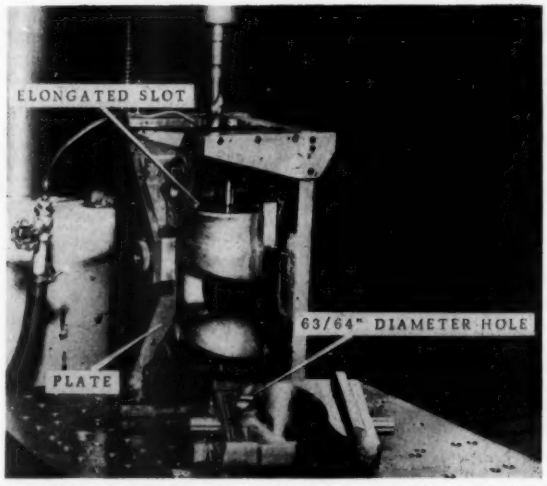


Fig. 5. Drilling titanium alloy, showing the back-up plate added to the original set-up for increased rigidity

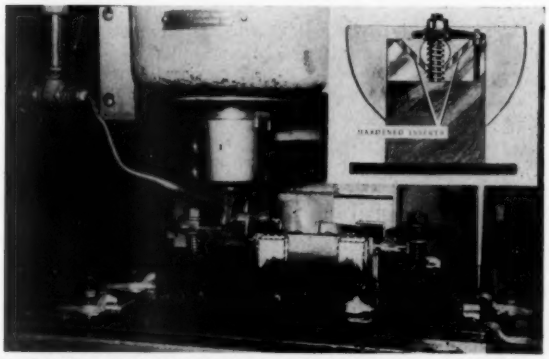


Fig. 6. Milling operation showing the two original side clamps and, in outline, the four side clamps inserted to provide added rigidity. The sketch shows the hardened steel inserts provided to prevent the part from embedding in the vee

in a detrimental effect on the finish of the part as well as on the tool life. The fixture was, therefore, redesigned to support the part in a horizontal position so that the cutting pressure would be directed on to the mill table. The added rigidity measurably increased the machining performance. Carbide cutters, operating at 200 sfm and 10 ipm, were employed for this test. Tool life, however, was still not entirely satisfactory, even though double arbor supports and flywheels were used.

Further problems were encountered in milling the part shown in Fig. 5. Although the holding fixture (Fig. 5) had been designed for limited production, it was changed to provide added rigidity and to minimize contact wear between the fixture and the part. Orginally there were only to side clamps near the bottom of the part. These were removed and four side clamps were inserted as near to the top surface as possible The end clamps, which held the round end lugs in a V, caused the part to embed in the V. These Vs were re-machined and hardened steel inserts added. The top surface and tongue projection of the part were then machined entirely satisfactorily with helical carbide end mills.

To machine the elongated slot in the part shown in Fig. 5, high speed steel end mills were used for plunging and elongating the slot. These end mills were flooded with sulphur base oil and were operated at 35 sfm. The results of this test were highly satisfactory.

For drilling the 63/64 in. dia hole in the part shown in Fig. 5, high speed drills were operated at 29 sfm with 0·006 in. feed per revolution with sulphur base oil. The base of the fixture was made from 1 in. thick aluminium plate while the legs were made from ½ in. thick triangular-shaped aluminium, tipped with hardened steel. The pressure exerted by the drill was sufficient to create a 0·030 in. bow in the base plate. To overcome this difficulty, a solid plate was attached between the side leg supports (Fig. 5). Additional clearance was cut in the end of the fixture to permit the drill press spindle to advance closer to the work so that a shorter drill could be used.

Tests were recently conducted with carbide cutters slotting forged AMS 4925 titanium. The results appear highly successful. These tests were made with a 14 in. dia, full radius, 0·375 in. wide, stagger-tooth slotting cutter. The cutter was tipped with C-2 carbide with +5° radial rake and +15° axial rake. The speeds and feeds were varied from 67 to 154 sfm and 1·500 to 6·375 ipm. The depth of cut was varied from 0·200 in. to 2·625 in., and the part was flooded with sulphur base oil. The clinging of chips was eliminated up to 25 sfm and a 0·011 in. chip load. This setting produced the best results; but when the surface speed or chip load was increased above this point, chips began to adhere to the cutting edges. While the results of this test appear highly satisfactory, only future tests will prove whether this procedure is the answer to present slotting difficulties or whether new methods will have to be sought.

Summary

The following summarized information should prove beneficial for the successful milling of titanium alloys.

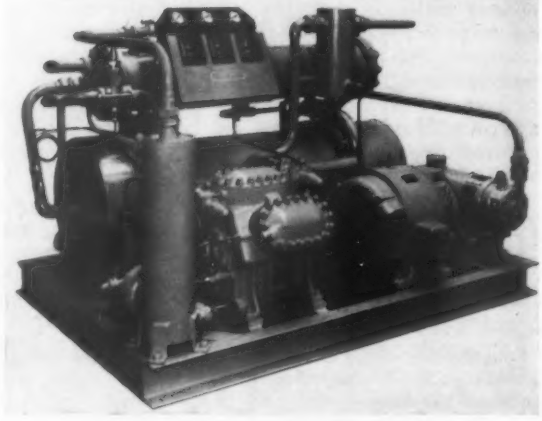
1. Avoid butt mill applications (high speed steel or carbide).
2. Use helical carbide slab mills (45° recommended).
3. For carbide end and slab mill operations, 80 to 120 sfm is recommended, and chip loads should be 0·005 to 0·015 in.
4. Apply coolant liberally, using sulphur base oil flow or spray mist coolants.
5. Insure the removal of chips to eliminate carry-through on successive cuts.
6. Check closely on cutting tool wear, removing dull tools immediately.
7. Use a conventional cut when scale is removed.
8. Avoid plunge cuts with carbide end mills.
9. Add hardened plates to fixtures when the part contact area is small.
10. Add back-up blocks to support the part when the cross-sectional area is small in relation to its length.
11. Use clamps at frequent intervals, clamping as close to the machining area as possible.
12. Design all fixtures for maximum rigidity.
13. Cut in the direction of maximum support.
14. If cast alloy cutters are used, they should be operated at 80 to 100 sfm with a 0·002 in. minimum chip load. The chips should be removed with a mounted wire brush.
15. High speed steel cutters should be operated at 30 to 50 sfm with a 0·002 to 0·005 in. chip load.
16. Shim slots for support when making outside cuts.
17. Support the sides of the parts to eliminate expansion when slots are being machined.
18. The use of carbide slotting cutters should be avoided pending further development.
19. Use double arbor supports and flywheels placed as close to the work piece as possible.
20. Use double keyways in slotting cutters.
21. Do not use stub arbors for arbor type slotting and facing cutters.
22. Do not stop milling cutters while they are engaged in a cut.
23. Carbide end mills should not be used for profiling when the length of contact between the part and the side of the end mill exceeds two-thirds of the end mill diameter.
24. During drilling operations, the drills must be backed out at frequent intervals to prevent the jamming of chips.

Packaged Water Chilling Unit

To meet an increasing demand from air conditioning engineers and industrial users of chilled water, The Lightfoot Refrigeration Company Limited of Wembley, Middlesex, have developed a new range of packaged water chilling equipment. These units available in graduated capacities from 10 to 100 hp, are specially designed to save space, and reduce installation time.

The smallest unit in the range, illustrated below has overall measurements of 6 ft × 4 ft × 3 ft 9 in. high. The refrigerating equipment, comprising Arcton 6 (F.12) compressor with motor, water cooled condenser, direct expansion cooler and chilled water circulating pump, together with controls, are mounted integrally on a rigid base of heavy section, welded steel channel which eliminates the necessity for special concrete foundations. The compressor is arranged for "no load" starting and the operation of the unit is entirely automatic.

Standard refrigerating equipment and controls have been used throughout the complete range of packaged water chillers and the units can be supplied to suit all standard electrical voltages.



The Lightfoot 10 hp packaged water chiller

Wire Drawing Plant

The new installation at the Kingfield Works of the Darwins Group

THE new Kingfield Works of Darwins Bright Steels Limited, officially opened last month by the Rt. Hon. Lord Riverdale, J.P., concentrates all the company's wire producing plant under one roof for greater working efficiency. The works consists of five bays each 112 ft 6 in. × 45 ft. In addition there is a building to house the electrical supply equipment and ablution block and a building for stocking wire coils with an adjacent test house.

No. 1 bay is given over to heat treatment. Here a spheroidizing furnace by the Electric Resistance Furnace Company Limited of the vertical cylindrical forced air type of 350 kW rating and having 3-zone control with a maximum temperature of 800° C, operates on the following cycle:

1. *Spheroidizing*. Heat up to 800° C, soak for 2 hr, cool rapidly to 720° C, soak for 4 hr and withdraw.

2. *Open Annealing*. Heat to 760° C, cool in furnace to 680° C, then withdraw.

3. *Sub-critical Annealing*. Heat to 700/720° C including a soak and then withdraw from furnace.

The furnace lid is electrically operated and lifts and travels to one side. A cylindrical inner baffle of heat resisting steel sheet encloses the charge and ensures that the air circulated by the fan passes uniformly over the charge and the heating elements in turn. The capacity of the furnace is four stacks of 30 in. dia coils, or alternatively, three stacks of 38 in. dia coils, giving an approximate weight of 3 tons per charge. The automatic temperature control instruments associated with the furnace are by Electroflo Meters Company Limited, the switchgear by Brookhirst Switchgear Limited and the oil circuit breaker by Geo. Ellison Limited.

Also in No. 1 bay is a pit pot annealing furnace by the Electric Resistance Furnace Company Limited of vertical cylindrical type and maximum temperature of 900° C. The furnace equipment consists of a contactor control cubicle, one instrument cubicle; housing; temperature controller and indicator, oil circuit breaker and three transportable pots each with atmosphere circulating fan, insulated head, removable suspension straps, etc. The equipment is capable of carrying out the following treatments:

1. *Bright sub-critical annealing*, at 700/800° C including a soak for 3 hr and using prepared protective atmosphere from the endothermic generator.

2. *Sub-critical annealing*. Without atmosphere and including a 'flashing' operation. The cycle of operation is as follows: A pot containing the charge is transferred to the cooling and the clamping bolts removed. The charge is raised from the pot for a few seconds to allow introduction of air. It is then lowered into position and allowed to cool in the normal way. This treatment produces very light scale.

Schumag combined drawing machine at the Kingfield Works.

3. *Annealing*, at 740/760° C without atmosphere and the charge cooled in the furnace to 680° C. The charge and pot are then withdrawn and subjected to the 'flashing' treatment.

4. *Annealing of high speed steel*, at maximum temperature of furnace, i.e. 900° C. The cycle consisting of heating to 900° C, soaking for 2 hr, cooling to 640° C and then withdraw. This process is carried out without atmosphere in the pot.

The equipment is suitable for charges up to a maximum diameter of 2 ft 9 in. and a stack of coils 7 ft 6 in. high. The furnace is rated at 175 kW on a 440 volt 3-phase 50 cycle supply, the casing is of mild steel construction and the insulation is 9 in. thick and a 3 in. lining of high alumina moulded design firebricks. A circulating fan is fitted to the removable heads of the pots. The temperature control gear is by Electroflo Meters Limited, control cubicle by Brookhirst Switchgear Limited and circuit breaker by Geo. Ellison Limited.

Charging the spheroidizing furnace.

The heat treatment bay, showing the spheroidizing furnace in the background.

The finishing and the despatch bay.

A pit type, heat treatment installation by Electric Resistance Furnace Company Limited, comprises: two pit type vertical cylindrical furnaces with two contactor control cubicles, two oil circuit breakers, two temperature control cubicles with Electroflo instruments, four charge carriers, one mild steel oil quench tank with Serck oil cooler, and one mild steel galvanized water quench tank. The maximum temperature here is 950° C with a rating of 120 kW. Each furnace is capable of giving an output of 22½ tons per 120-hr week and is suitable for taking a charge of coils 32 in. dia and 8 ft high, each coil weighing 1 cwt. The furnaces are to be used for annealing, normalizing, hardening and tempering of carbon steel rods in coil form.

A further furnace is of the pit pot, vertical cylindrical annealing type and is by Junkers. It is of 80 kW rating and has two-zone control and a maximum temperature of 900° C. This furnace is used for annealing, normalizing and also for bright annealing with protective atmosphere. There are four removable pots complete with heads which will take a maximum coil diameter of 26 in., the loading of each pot being between 10/12 cwt.

There is also a gas-fired annealing furnace, reconstructed by Fuel Furnaces Limited, for annealing coils of wire. The furnace is fired by towns gas through 12 high power injector type burners which are controlled by a motorized gas valve through Transitrol anticipatory temperature controllers of the self-contained direct deflexion type made by Ether Limited; the range is 0/1100° C.

A Riley 2-ton E.O.T. crane is provided with floor controlled 2-speed hoist.

All the cooling water is gravity fed to the furnaces and water quench tank and returned to the overhead supply tank.

The equipment in No. 2 bay is for the cleaning or descaling of wire and wire rod coils after treatment. Here there is a sodium hydride descaling plant, electrically heated and with two ammonia crackers, an EFCo–Virgo descaling plant, gas heated and fitted with electrically operated lid; a fully screened water quenching tank, pneumatically operated double doors with sub-floor quenching, and seven brick pickling tanks for hot water, sulphuric acid, hydrochloric acid, nitric-hydrofluoric acid, nitric acid, water spray and lime. There is also a rod baker by Electric Resistance Furnace Company Limited, of the top-charged, double-case type and provided with forced air circulation. The unit is suitable for baking of rod in coil form at temperatures varying between 200° C and 300° C with a maximum temperature of 400° C. The rating is 90 kW from two heater units. The approximate output is two to three tons per hour with coils up to 3 ft 6 in. outside diameter.

The top case sliding doors are pneumatically operated by double acting cylinders. The automatic temperature control gear is of Electroflo indicating type and there is also an expansion type thermostat fitted adjacent to each heater to interrupt the supply to the heater and fan motor should the temperature exceed the set predetermined figure.

A 2 ton Riley E.O.T. crane, floor controlled, serves the entire floor area.

The wire drawing is done in No. 3 and 4 bays. In No. 3 bay there are two Farmer Norton machines, one being a 9-hole machine capable of drawing wire of 0·082 in. to 0·042 in. dia in nine passes or ranges down to 0·018 in. The second Farmer Norton machine is of the 4-hole type capable of drawing from 0·212 in. down to a finished size of 0·102 in. dia.

There is a 26 in. hot wire drawing block with infinitely variable speed between 50 to 200 fpm provided by a Heenan and Froude coupling. The block is for drawing high speed steel wire which is heated in a

graphite bath, baking oven and lead bath furnace. The size range is between 0·330 in. to 0·035 in. dia.

Eight single wire drawing blocks, two of 22 in., three of 18 in. and three of 12 in. are capable of drawing wire of up to 0·550 in. to a finishing size down to 0·018 in.

There are two machines in No. 4 bay. One is a Crossley 8-block wire drawing machine and the other a Schumag combined machine for drawing, cutting, straightening and polishing rounds as well as for drawing, cutting and straightening of squares and hexagons. It is adapted for both steel and iron and its range is: rounds, 0·158 in. to 0·512 in. dia; squares 0·158 in. to 0·472 in. across flats; hexagon, 0·196 in. to 0·512 in. across flats. The bar length is from 2 to 4 metres and the drawing speed 40 metres per minute with a maximum pull 3000 kg.

All the facilities required for finishing are provided in No. 5 bay. There are three straightening and cutting off machines capable of handling materials from 0·400 in. diameter down to 0·048 in. dia and up to 16 ft long. There is one of the latest type Wafios automatic wire straightening and cutting off machines with flying shear. The machine has infinitely variable wire feed and is capable of automatically straightening and cutting off wires made of brass, copper, phosphor bronze, german silver, etc., in wire gauges from 0·092 in. to 0·276 in. dia, high carbon wires from 0·092 in. to 0·229 in. dia, the shortest lengths are 6 in. and the longest about 13 ft 1 in. but this can be increased by additional straightening extensions.

Other finishing equipment includes a Robertson reeling machine, a Schumag centreless grinding and polishing machine with a range from 0·078 in. up to 0·518 dia, a Lidkoping No. 2 centreless grinding machine with latest type of Phillips clarifier for swarf separation, and range from 0·004 in. to 0·800 in. dia and up to 10 ft in length, two Scrivener centreless grinding machines with a range from 0·040 in. to 0·500 in. dia, a Speedax high speed abrasive cutting off machine of capacity up to 1 in. dia and any length, a Ballinger abrasive cutting off machine of capacity up to 1¼ in. dia, any length and a Canning wire polishing machine. A 2-ton Riley E.O.T. crane, floor controlled, covers the area.

In addition to the three cranes mentioned, a 2-ton Ransome, Sims & Jeffries fork lift truck with a 6 ft boom is available for handling the coils of wire.

Low Voltage Fluorescent Lighting

One of the most significant developments in fluorescent lighting in recent years is the introduction of a range of low-voltage fluorescent light units which can operate from either a 12 or 24 V d.c. source. These units which were developed jointly by The Plessey Company Limited and Easco Electrical (Holdings) Limited, are now being applied extensively to industrial and commercial lighting and are being marketed in Britain by the latter Company and overseas by Plessey International Limited.

Apart from their portability, quick-starting and suitability for use in confined spaces, the light and compact Eascolyte units provide two to three times the light obtained from an equivalent filament lamp and, as they operate from a low-voltage battery supply, are particularly suitable for use in situations where there is the risk of electric shock.

Conversions from a d.c. to an a.c. supply is carried out by means of a Plessey vibrator working at a frequency of 200 c/s, an arrangement which dispenses with the need for rotary converters or motor generator sets. A single-pole switch in the live line from the battery is sufficient to operate the unit. This may be integral with the fitting or placed at any convenient part of the battery lead wires. The power pack, which may either be mounted in the lamp fitting, or remote from it, is manufactured by The Plessey Company Limited, Ilford, Essex.

The starting system employed is of the "instant start" variety, in that the full striking voltage is applied to the lamp at the moment of switching on, and there is no delay switch. In addition, the units will also operate under large variations of input voltages and continue to operate when only 75% of the nominal voltage is applied to the power pack.

The C 21 unit, operating from a 12 V and 24–28 V d.c. supply is gas- and water-tight and is suitable for operation in most situations where fire hazard may be present; as it is water-tight it is particularly suitable for aircraft maintenance work carried out either indoors or outdoors. Twin 18 in. 15 watt fluorescent instant start lamps are employed which are housed in a stove-enamelled, corrosion resistant aluminium alloy case. Perspex lenses are sealed in position by a retaining frame fitted with rubber gaskets. Control equipment is mounted on a steel chassis, stove-enamelled white, which can be easily removed after detaching the lens. The units may be operated individually from the supply, or, alternatively, a number may be tandem connected, up to a maximum of six, where such an arrangement is desirable. The C.21 unit measures approximately 19 × 15 in. overall and weighs 18 lb, the consumption is 50 W.

For all indoor or enclosed situations, the Eascolyte combined fitting and power unit C.26 and C.25 respectively is available which may be flush-mounted, either on a ceiling or wall, provided there is sufficient clearance at the rear of the unit. Where it is impossible to accommodate the integral power unit, the lighting fittings may be mounted remotely from the power unit, provided there is reasonable access for maintenance. The approximate total consumption is 16 W.

Specially designed for use as a portable or "Wanderlead" fluorescent light source is the "Sticklyte" unit type C.27 which operates from a 12 or 24 V d.c. supply. The rating is 8 W.

Benchside Fire Extinguisher

An inexpensive fire fighting appliance, which can be located beside each work-bench or machine, to deal instantly with minor outbreaks of fire has been developed by Deb Chemical Proprietaries Limited, Belper, Derbyshire.

The Gwish Aerosol fire extinguisher, which is less than one third the cost of normal type extinguishers contains 12 fluid oz of extinguishing liquid, released as a powerful jet spray by depressing the discharge nozzle, release of the nozzle completely cuts off the jet. The spray douses flames instantly and carries for 6-ft with a 3-ft dia coverage. The extinguishing fluid used is a non-conductor of electricity, consequently Gwish is safe and effective on all fires whatever their cause. The cost of the Gwish complete with fixing brackets is 12/11d. each.

Cemented Carbide Turning Tools

A review of application technique

By A. G. GARDNER, A.I.M.

CEMENTED carbide is now well established as a cutting tool material. Its hardness and its strength in compression are greatly superior to those of steel. The excellent cutting characteristics of cemented carbide are chiefly due to the manner in which hardness is maintained at temperatures up to 600–700° C. As a result, carbide tools will cut at speeds greatly exceeding the maximum possible with high speed steel. In addition, many materials once thought unmachinable can now be machined and these include 12% manganese steel and high tensile steels of up to 100 tons per square inch. Carbide form tools have been found especially useful due to their slow change in shape from wear on repetition work—an important feature in elaborate tool set-ups.

In spite of the now widespread use of carbide tools they are too often incorrectly applied, often by being given the same treatment as high-speed steel. The purpose of this article is to enable users of carbide tools to obtain the maximum benefit from them.

Cemented carbide consists basically of very hard and fine carbide particles embedded in a soft, tough alloy. This can be seen in the photomicrograph, Fig. 1. The sharp angular particles are tungsten carbide; these particles are "cemented" together by cobalt which is the material between the carbide grains. The amount of "cement" or bond depends on the application of the carbide. The hardest grade contains the least amount of bond, but is also the most brittle. This is used for machining chilled iron rolls and for fine cuts on cast iron, aluminium and aluminium alloys. As the amount of bond is increased, hardness decreases but toughness becomes greater. Tough grades are used where the rigidity usually demanded for carbide tools cannot be obtained. They will withstand severe intermittent cutting.

Fig. 1. Photomicrograph of 'straight' tungsten carbide-cobalt structure, used for machining cast-iron and non-ferrous metals and alloys

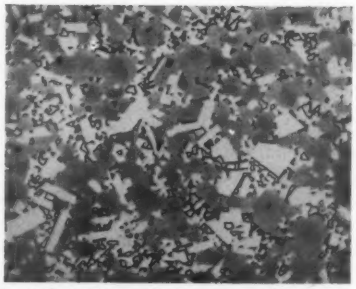


Fig. 2. Photomicrograph of tungsten carbide-titanium carbide-cobalt structure, used for machining steel

Tungsten carbide is the chief constituent always present in the carbide used for cutting tools and the bond, as already mentioned, is usually cobalt. In addition, titanium carbide is also present in the steel cutting grades. This is because although straight tungsten carbide-cobalt compositions are very successful for most non-ferrous alloys and cast iron, they show an effect known as "cratering" when used for turning steel. Steels usually give long helical turnings and the main contact of the chip with the cutting tool is not at the cutting edge, but some distance to the rear of it. The rapidly moving hot turning rubs the surface, resulting in tearing out of carbide grains which eventually causes the formation of a crater. This enlarges and finally the tip breaks off. This effect can be eliminated by using tungsten carbide compositions containing titanium carbide. A photomicrograph of one of these steel cutting compositions is shown in Fig. 2. It will be seen that there are rounded grains present due to the titanium carbide in addition to the angular tungsten carbide grains shown in Fig. 1.

Mounting tool tips

Although probably the majority of carbide users buy their tools as integral units with the tips already brazed on the shanks, there are nevertheless still a fair number of users who prefer to mount the carbide tips themselves. For this reason, the mounting technique will be briefly described.

The shank of the cutting tool should be of good quality carbon steel with a carbon content of 0·5 to 0·6%. After the base of the tool has been given a reasonably accurate locating surface by machining or surface grinding, the approach trail and clearance angles are formed by grinding or milling. All secondary or shank clearances should be 3° greater than those required on the tip so that only the tips need to be ground after brazing.

The most commonly used form of seating for the tip is shown in Fig. 3. This supports the tip adequately against the three pressures: top. side and back. The base of the seating should always be flat and its form coinciding with that of the tip in order to ensure uniform thickness of brazing material.

The three chief metals used for brazing are copper, Sif-bronze and silver solder. Although copper gives the strongest joint, it is necessary to use a furnace with a non-oxidizing atmospheric and most users prefer Sif-bronze or silver solder. Sif-bronze can be torch brazed whilst silver solder with a much lower melting point is simplest to use.

There is an appreciable difference in the thermal expansions of cemented carbide and steel. This

can lead to stresses being set up as a result of brazing. These stresses are usually shown up during grinding as cracks running parallel with the joint. These cracks are not to be confused with those due to poor grinding technique. Various inserts are used to minimize brazing stresses and a thin sheet of suitable material is often placed between tip and shank. A sheet of iron gauze has been found fairly satisfactory. The braze metal in the form of sheet should then be placed on either side of the iron gauze.

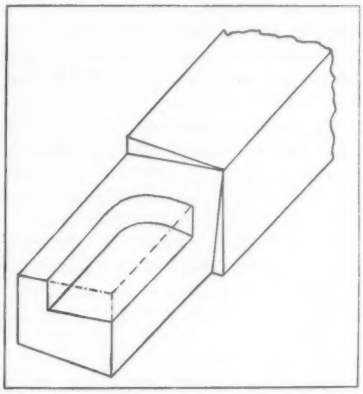


Fig. 3. Type of seating commonly employed for carbide tips

Design features of carbide tools

An appreciation of the basic principles involved in the design of carbide tools should assist in their correct application. These tools should never be misused by employing similar clearances and rakes to high-speed steel tools, a practice which only leads to wastage of valuable tip material.

Cemented carbides are very strong in compression but comparatively weak in impact or shear. For this reason, and also for economy in material, for turning tools they are almost invariably used in the form of tips or inserts secured to steel shanks. The tool must, therefore, be designed so that the tip will be stressed in compression only. This means giving the tip the greatest possible support by means of a suitably shaped seating and by using the minimum clearance angle.

When a tool is used for turning there are three forces which act upon it. There is a force against the side of the tool and parallel to the axis of the work. There is a radial force which presses against the nose of the tool in a direction perpendicular to the axis. Finally, there is the tangential pressure directed vertically downwards on top of the tool. It is the resultant of these three forces which influences the type of seating and other details, such as thickness of the tip, and the depth and shape of shank. The type of seating shown in Fig. 3 gives good support against the three forces described above, thus ensuring the carbide is always in compression.

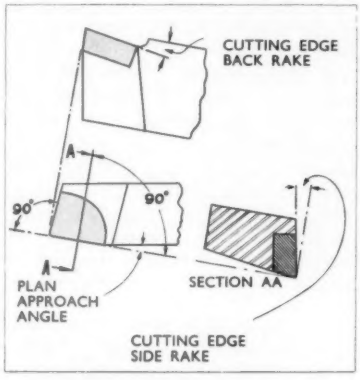


Fig. 4. Principal tool cutting angles

As regards the shank, a square section is used where the cutting pressure is applied in a direction which produces a twisting effect on the tool. The shank should have the largest possible section with cranked tools, since the point of applied pressure is out of line with the tool support. There is usually only vertical pressure on straight shank tools and the deepest possible shank is used to avoid bending. Width in this case depends on the number of regrinds to be expected from the tip.

The various tool angles and radii are shown in Figs. 4, 5, and 6. The names given for tool angles are those which have been generally agreed to and alternatives are only given where these are still fairly widely used. These features will now be considered in connection with the design requirements of cemented carbide.

Cutting edge side rake (*side top rake*), Fig. 4, is the angle between the base and the face, measured in a plane at right angles to that of the plan approach angle. This is the angle which parts the chip from the work and should not be confused with front top rake. Cutting rake is usually determined by the cutting pressure exerted on the turning tool. Mild steel and light alloys require very little horse-power to part the chip from the work-piece and the cutting pressures are therefore light and high positive rakes are suitable. Aluminium and its alloys tend to form a built-up edge on the tip and there are special grades of carbide for helping to overcome this difficulty. Materials such as high tensile steel which require heavy cutting pressure need the use of negative

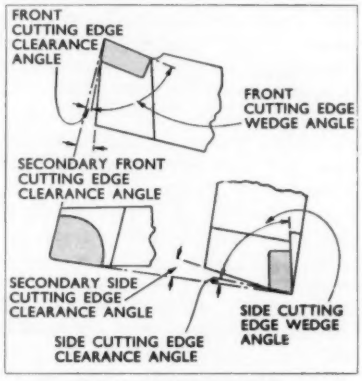


Fig. 5. Tool clearance angles

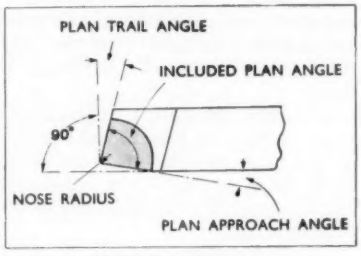


Fig. 6. Tool plan angles

cutting rakes in order to provide a cutting edge able to withstand the higher pressures. Negative rake directs the chip thrust away from the cutting edge where the tip is weak, into the body of the tool. There is consequently less tendency for the tool to dig in. Table I gives a range of materials and shows how they are related to cutting rake.

Some extra power is taken by negative rake turning which is largely absorbed in heating the chip. The chip is softened and its pressure effectively reduced. It is not recommended that negative rake turning should be used on alloy steels which retain their strength at high temperatures.

Cutting edge back rake (*front top rake*), Fig. 4, is the angle between the base and the face, measured in a plane parallel to the plan approach angle. It is recommended that when-

ever possible a negative front top rake angle should be used, i.e., sloping down from the back to the front of the tool. This induces a shearing cut which tends to guide the chip in a direction away from the workpiece and avoids damage to the finish. The lowest point of the cutting edge is at the point of deepest cut and there is, therefore, less tendency for the point of a cutting tool to dig in when a negative front top rake is used. This results in less front clearance wear since chip pressure is exerted in a direction away from the work.

Clearance angle, Fig. 5, is the angle between a line at right angles to the base and that portion of the flank immediately below any cutting edge measured at right angles to that edge. Clearance angles are associated with their respective edges, e.g., side cutting edge clearance angle, front cutting edge clearance angle, nose clearance angle.

Side and front clearance angles should be just sufficient to avoid the work. Since the shear strength of cemented carbide is low, too great a clearance angle weakens the cutting edge, especially if the tip is thin.

Secondary clearance angle is the angle between a line at right angles to the base and that portion of the flank situated below the clearance angle measured at right angles to the cutting edge.

The secondary clearance angle should be between 2° and 4° greater than the clearance required on the tip. This is sufficient to avoid grinding the steel shank with the soft green grit wheels used for the tip and results in greater economy in grinding wheels. Secondary clearance angles are associated with their respective edges, e.g., side cutting edge secondary clearance angle.

Wedge angle, Fig. 5, is the included angle between the face and that portion of the flank forming the clearance angles, measured at right angles to the edge. Wedge angles are associated with their respective edges, e.g., front cutting edge wedge angle.

Plan approach angle, Fig. 6, is the angle between the side of the shank and the cutting edge and may be as much as 45°. For most cases an angle of 10° is best, unless it is necessary to machine square to a shoulder when the approach angle is, of course, zero. On starting the cut a proper approach angle results in the initial load being taken a little way back from the nose of the tool where the tip is stronger. The approach angle determines the length of the cutting edge, which should be as long as practicable. This is in order to distribute the chip pressure along it as much as possible. If the cutting edge is excessively long, chatter is sometimes induced, although this can be caused by insufficient rigidity of the workpiece. Where this trouble is due to length of cutting edge, the approach angle should be reduced to the point where chatter is eliminated. Chips of curved cross section produced by round-nosed or shaper tools require more power for their removal because they are deformed in flowing over the tool surfaces.

Table I.—CUTTING RAKE FOR VARIOUS MATERIALS

Material	Cutting Rake Angle (Degrees)
Light alloys	12—14 Positive rake
Free cutting mild steel	9 Positive rake
Mild steel	7 Positive rake
Carbon steel	4—5 Positive rake
Cast-iron	3 Positive rake
Brass and bronze	0 Positive rake
30—40 ton steel forgings	1—2 Negative rake
50 tons steel	3 Negative rake
65—75 tons steel	5 Negative rake
100 tons steel	8 Negative rake

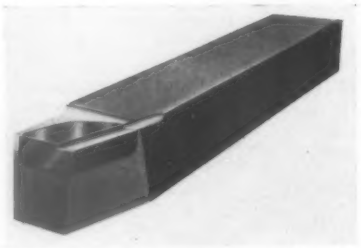


Fig. 7. Appearance of correctly ground chip breaker rebate

Nose radius, Fig. 6, should be kept as small as possible when turning steel. Instead of a parallel chip thinning at one edge, a large nose radius may produce a chip like a thin curved wedge. This produces excessive chip pressure immediately behind the cutting edge, causing cratering which leads to chattering, bad surface finish and early collapse of the cutting edge. It is, however, advisable to increase the nose radius for an interrupted cut.

Plan trail angle, Fig. 6, is the clearance angle between the workpiece and the trailing edge of the tool. This should be just sufficient to avoid the work. There will then be maximum resistance to pressure at the tool point in the direction of travel. Too great an angle weakens the cutting edge, especially if the tip is thin.

Chip breakers

When steel is machined it produces a long hot flexible chip. Owing to the very rapid rate of metal removal when carbide tipped tools are used, there would be danger to the operator and inconvenience in disposal of the turnings unless these were controlled and broken up.

There are several ways in which this can be accomplished and the easiest method is to grind a rebate or step along the cutting edge of the tool (Fig. 7). This rebate must have the effect of turning the chip into a tight curl which will break into short lengths. It is impossible to give any hard and fast rule for dimensions as every job has its particular variations, such as feed, depth of cut and material being machined, but the conditions to be satisfied are:

(1) The chip must be curled short enough to break.
(2) The chip must not be so tight as to put excessive pressure on the machine or tool.

It is always wise to start with a rebate of minimum dimensions as it can be ground wider or deeper without wastage of the tip, whereas the front or the top of the carbide tip must be ground away to make it narrower or more shallow. A fairly average chip control rebate would be 0·020 in. deep by $\frac{3}{32}$ in. wide.

It is important that the rebate should be correctly ground. The tool should be set up in a tool and cutter grinder at the correct angle and the rebate ground with a diamond wheel. A metal-bonded wheel with a copious supply of water as coolant should be used as it holds the radius on the corner better than will a resin-bonded wheel.

Chip breaking can often be achieved by increasing the feed to obtain a chip of larger cross-sectional area which breaks more easily. Rapid cooling at high velocity also induces a broken chip.

Machining operations

The machine should be capable of supplying the necessary horse-

power for removing metal at the maximum rate it is intended to use.

Damage to the tip will result if the machine stalls while the tool is cutting. The drive must, therefore, transmit the load without slipping. Should the machine stall with the feed engaged, the power should be cut off and the tool withdrawn from the work. Normally the feed should always be disengaged before stopping the machine.

As carbide can be used for cutting at higher speeds than with tool steels, all fixtures holding the work should be given careful attention. Where centres are used for turning these should preferably be of the running type in order to avoid overheating which would arise with fixed centres. Carbide tipped fixed centres can, however, be employed for light cuts.

The tool post must be capable of holding the tool very firmly and as close to the work as practicable. A flat-bottomed tool post fitted with flat-ended clamping screws is best. With this type of tool post it is a simple matter to pack up the tool to the required height with shims. Overhang of the tool from the tool post should be as small as possible. If, however, the tool layout calls for a large tool overhang, then tool life can be improved by increasing the depth of shank.

Tool setting

When negative rake tools are used the point of the tool should be set just below centre. When the cutting rake is positive the setting is more critical since if the tool point is above or below centre this will modify the cutting rake and front clearance. With the tool set above centre the effective top rake is increased and the front clearance is reduced, often resulting in ineffective cutting. With the tool set below centre the top rake is reduced and this increases chip pressure on the top of the tip. This could cause the cutting edge to collapse because the front clearance would then be greater than required.

Cutting speed

The peripheral or surface speed of the work with respect to the tool is not only higher but is more critical in determining life between regrinds of cemented carbide as compared with high-speed tools. However, a reasonable margin still exists in cutting speed. The usual indication of too low a cutting speed is the development of a built-up edge on the carbide tool. This causes an alteration in the direction of the cutting forces and could result in complete collapse of the cutting edge. If this does not happen, the build-up may disappear and reform at intervals and so give poor surface finish and short tool life. Increasing the speed will eventually eliminate the built-up edge. Excessive speed is, however, equally to be avoided since it will cause the cutting edge to burn and wear away rapidly.

Actual cutting speeds will, of course, depend on the material to be turned. Every material has an optimum cutting speed that will give the maximum tool life for the maximum metal removal rate, and

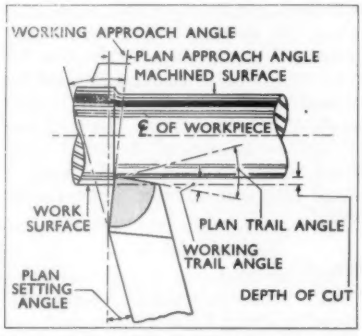


Fig. 8. Tool set up and angles involved in turning

this is determined by taking a check-cut at various speeds; the lowest speed which shows sudden improvement in finish is that which should be used for normal machining operations. The speed is not so critical for cast-iron and non-ferrous materials as it is for steel.

It is recommended that users should follow manufacturers' machining data on this question and full particulars are available for each grade of carbide.

Feed

Once a suitable cutting speed has been arrived at, the next variable to decide is tool feed. This is the distance travelled by a tool per revolution, designated as inches per minute or inches per revolution.

When the cutting edge first touches the workpiece, spring in the tool and the resistance to penetration of the work causes an initial rub, until the machine forces a penetration by the cutting edge. During this first stage the rubbing causes some damage to the front clearance. The life of a tool is, therefore, determined by the number of starting cuts during its life rather than the amount of surface area machined. It will hence be appreciated that once the tool has been started on the work it must always be cutting and never rubbing. In order to achieve this a feed of 0·010–0·020 in. per revolution is advisable. Finer feeds can be used if the cutting edge has been lapped by a fine diamond wheel so that it will be sharp enough to take the increased wear.

Depth of cut

Roughing cuts are mainly governed by the power available from the machine. It is important that the depth of cut be sufficient to keep the nose of the tool underneath the surface scale. Scale on castings has rather an abrasive action on the normal steel-cutting grades of carbide and a preliminary cut with one of the grades used for cast iron will often be found more effective.

The depth of cut which may be safely taken is also affected by the rigidity of the cutting tool, as well as the chuck and all holding fixtures.

The finishing cut should not be less than 0·005 in., otherwise the work is concentrated at the nose of the tool which wears away rapidly because of the overheating. The shallower the cut the more attention should be paid to keeping a good finish on the cutting edge.

Coolants

Tool life is increased and surface finish maintained if a coolant is used when cutting. The coolant which will be found suitable for the majority of applications is soluble oil. Plenty of coolant should be applied at high velocity right on the nose of the tool. Any tendency towards alternate cooling and heating should be avoided as it is likely to cause the tip to crack. If it is not found possible to use a coolant in the correct manner it is better to machine dry.

There are, of course, machining applications where it is more advantageous to machine dry in spite of a shorter tool life. The ability of cemented carbide to stand

up to high temperatures and retain a cutting edge is one of its outstanding features.

Grinding technique

The successful use of cemented carbide tools depends upon their correct grinding. This latter operation is preferably carried out on a machine specially designed for sharpening carbide tools. This machine should ideally incorporate the following features.

Machine specification for off-hand grinding

The tool fixture should be fitted with a graduated scale and be capable of adjustment to any required angle. The fixture should also be capable of adjustment towards or away from the wheel to compensate for wheel wear. A protractor type work-holder or universal vice can be used on a fixed tool rest table to ensure the production of accurate tool angles. Driving spindles should be free from vibration and end play in order to prevent wear of the grinding wheel and unsatisfactory grinding conditions. The machine should preferably have a reversible motor in order that right- and left-hand tools may be ground on the same wheel or wheels. If wet grinding is to be used the supply of coolant must be ample for the job. If more than one size of grinding wheel is to be employed, there should be some means of varying the spindle speed in order to maintain a nearly constant peripheral speed.

Mounting wheels

Care should be taken in mounting wheels to see that they run true on the machine spindles. This is especially necessary with diamond wheels. These are made with their arbor holes a few thousandths of an inch oversize to provide for a setting up adjustment to individual mountings. Initially, the clamping nut should be tightened just sufficiently to hold the wheel secure. The wheel is then accurately located on its spindle by using a clock gauge against the periphery. Points of greatest projection should be gently tapped, using a block of wood as a cushion, until the periphery runs true to within 0·0005 in. The wheel should then be clamped tightly in position.

Coolants

Both vitrified and metal bonded diamond wheels can be used for grinding dry, but the use of a coolant of either plain water or soda solution is recommended, as it will serve to keep the work cool and the cutting face clear. A copious flow of coolant should be applied under pressure at the point of contact of the tool with the wheel.

The use of a coolant is advisable with all operations involving resin-bonded wheels since excessive grinding temperatures will char and weaken the bond. For resinoid wheel grinding, suitable coolants range from water through paraffin oil, water-soluble oils, light lubricating oils, to olive oil or ground-nut oil. These coolants have been quoted in order of freeness of cutting, commencing with the coarsest. The last mentioned gives the highest degree of finish and the longest wheel life. The amount of coolant required for diamond impregnated resinoid wheels is extremely small, especially where oil is required, as it is only necessary to maintain a thin film for lubrication. This can be applied by means of a felt pad held lightly against the wheel face. The pad can be fed by means of a metal tube fitted with a control cock from a small reservoir situated close to the wheel.

Wheel speed

The recommended peripheral speed is about 5500 surface feet per minute, using a hand pressure of 5 to 7 lb. The speed should not fall below 4500 surface feet per minute in the case of resinoid wheels. Metal and vitrified wheels are not quite so critical. Excessively high speeds generate heat and cause cracking.

Off-hand grinding operations

The wheels required for grinding carbide tipped tools are:

(a) For the shank—aluminium oxide.
(b) For rough and finish grinding of the tip—silicon carbide
(c) For lapping the tip—diamond.

There is a proper sequence of off-hand grinding operations from the preliminary rough grinding, through to the final lapping.

The first step is to grind the secondary front and side clearance angles on the steel shank. These should be 2° to 4° greater than the clearance angles required on the finished ground tip. This will prevent clogging and excessive wear of the silicon and carbide wheel when grinding the tip. Secondly, rough and finish grind the tip. Thirdly, diamond lap the tip to give a fine finish. Where the usage of carbide tools is too small to justify the expense of diamond wheels, remarkably good results can still be obtained by omitting the lapping operation.

The periphery of the wheel can be used for fast grinding of a broken edge but to ensure that the tool is not concave and weakened under the cutting edge, a finish grinding operation should be carried out on the side of the grinding wheel.

Normally, tools withdrawn from work at the right time require only finish grinding or lapping to fit them for further use and it is unnecessary to regrind secondary clearances. The order of operations for tip grinding are, however, always the same, i.e., cutting rake, front clearance, side clearance and nose radius if required.

When grinding free-hand the operator should remember to use the lightest possible pressure in order to avoid developing great heat in the tip, with consequent risk of cracking.

The grinding wheel should always rotate into the carbide tool and not away from it. If the grinding wheel rotates away from the tool, particles of unsupported carbide grains may flake off from the cutting edge, leaving minute irregularities which can seriously affect the tool performance.

Dressing and truing

Regular dressing and truing is necessary with vitrified and metal-bonded grinding wheels as they tend to load and glaze, especially when used dry. The wheels may be dressed with a silicon carbide stick. In the case of cup or dish wheels, these may be dismounted and rubbed by hand in a circular motion on a sheet of glass covered with 100 grit Carborundum previously mixed with water to a very thin paste.

Resinoid wheels should be dressed and trued only as occasion demands, otherwise too much of the expensive diamond will be lost. Cup or dish wheels can be treated as already described above. Peripheral wheels should first be trued on the spindle as for mounting until maximum truth is obtained, and then finally dressed by means of a silicon carbide stick.

Recommended wheel types

As a guide to the wheels to be used for grinding, the wheel makers' recommendations are given below:

Table II.—RECOMMENDED WHEEL TYPES

Operation	Carborundum	Norton	Universal
Roughing	G.C.60 -J-VG.	39C60 J7V	C46LV.
Finishing	G.C.120-J-VWG	39C90 J7V	C100IV.
Lapping	Diamond 220-2B	Diamond 220-C50	Diamond 220

Causes of tool failures

As an aid to the rapid determination of causes of tool failure, symptoms and their usual causes are classified as follows:

A. Undue wear of the cutting edge.

Causes:

(1) Examine the cutting edge with a hand lens. It may be minutely chipped rather than worn; if so, refer to section B below.

(2) Excessive speeds cause rapid wear.

(3) Too large a nose radius on tool.

(4) The cutting clearances can cause dragging, if those are made too small.

(5) Incorrect carbide grade: consult manufacturers' recommendations.

B. Chipping of the cutting edge.

Causes:

(1) Too slow a speed may be producing a built-up edge.

(2) The chip breaker width may not be sufficient. If the chip is too tight it may exert pressure on the cutting edge.

(3) Supply of coolant insufficient. The alternate heating and cooling can crack the tip.

(4) Ensure that the correct carbide grade is being used for the job.

C. Chattering of the tool.

Causes:

(1) Excessive overhang of the tool is a frequent cause.

(2) Work supports not firm enough; this can induce vibration.

(3) Too light a feed.

(4) The plan approach angle may be too large.

(5) The point radius may be too large.

(6) Tool requires resharpening; dull tools will chatter quite readily.

(7) Plan trail angle too small; the tool will drag and chatter.

D. Poor surface finish.

Causes:

(1) Too slow a speed resulting in a built-up edge.

(2) Turned surface may be receiving damage from chips. Try the effect of an angular chip breaker if machining steel as this will turn the cuttings away from the turned surface. Alternatively, try a smaller point radius.

E. Chips not breaking up.

Causes:

(1) Chip breaker dimensions may be incorrect; the chip is too tight or too loose in the groove.

(2) Insufficient coolant at high velocity.

(3) The point radius of the tool may be too large. This results in a distorted chip which is difficult to control.

In conclusion, the author wishes to express his indebtedness to Firth Brown Tools Limited for supplying the illustrations used in this article.

Transporting on Stairs

A lightweight versatile hand-truck which can handle loads up and down stairs as well as on the level is to be marketed in this country by Industrial Trucks Limited, of Essex Road, Acton W3.

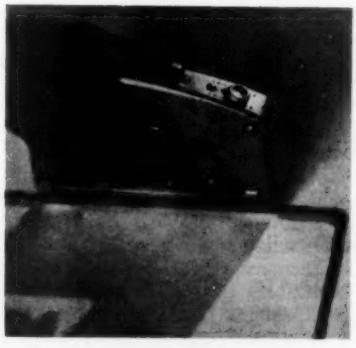
Known as the Stepmaster, the truck is extremely light, being constructed of high duty aluminium alloy to enable one man to carry weights up to one cwt up a staircase.

The movement of the truck up and down stairs is achieved by releasing a pair of retractable crawler tracks which are held by a lever-catch to lie flat up against the underside of the truck when in normal use on the level. The tracks are of sufficient length to span the stair treads and each comprises of a belt supported on a chain of rollers, with screw adjustment provided to take up any slack. Once the staircase is negotiated the tracks and their support plate are quickly folded and the load transported on 8 in. dia cushioned tyred wheels.

Left, the Stepmaster truck negotiates a staircase with ease. Above, close up showing the tracks gripping the steps

Rapid Cable Stapling

Specially developed for speeding up electrical cable laying the Titan cable tacker fires a curved roof staple in position simply by depressing a handle. The base plate is shaped so that it can be laid along the cable and an impact selector enables a hard or soft strike to be selected depending upon the material into which the staples have to be driven. The makers are Industrial Staplers Limited, 7/9 Rathbone Street, London W1.



The base plate of the tacker is shaped so that it can be laid along the length of the cable

technique

devoted to the discussion of practical problems. Readers are invited to contribute items from their own experience in matters relating to design, manufacture and maintenance. Payment will be made for published contributions.

Any Questions ? We welcome inquiries concerning difficulties arising out of our readers' general work, for treatment in the **technique** section. The full name and address of the writer (not necessarily for publication) must accompany each communication

Transfer Mechanism for Reversing Work on an Automatic

In view of the present interest in transfer equipment for automation it may be worth while giving some particulars of a successful tool designed and worked successfully some twenty years ago.

It was at a time when a shortage of special tube—unobtainable in the required outside diameter and material—led to the usual practice of pressing the pieces from strip material in the form of a shell as seen at Fig. 1A, and then subsequently completing the machining on an automatic of the six spindle type in order to remove the bottom of the shell and to chamfer the forthcoming tubular detail in the manner illustrated at 1B of this drawing. The operation was made somewhat complex by the workpiece requiring reversing in the collet for the completion of the opposite end. The actual direction in which the workpiece was inserted was unimportant because the arrangement of dual parting tools in the cutting cycle made it possible to remove the shell end either initially or at the second stage; thus the pieces were gravity fed down a chute and simply pushed into the collet with either the open or closed end facing the tools.

With a shell in the collet the machine slide carrying a parting tool advanced. The shell was set back against a stop inside the collet and if the curved portion faced outwards it was cut off by the tool. With the open end initially facing the tool, material was still removed, thus facing the end and providing for the finished shell being accurate as to length. Countersinking came next, with a tool in the same setting to remove the sharp burr left by the parting tool.

The next step was to remove the shell from the collet, grip it gently just prior to falling clear, reverse it to bring the opposite end facing the tools, and finally grip it in the collet for the second operation. It was for this work that the reversing mechanism illustrated at Fig. 2 was devised.

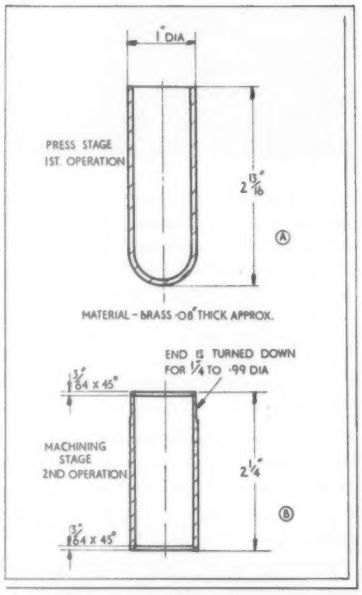
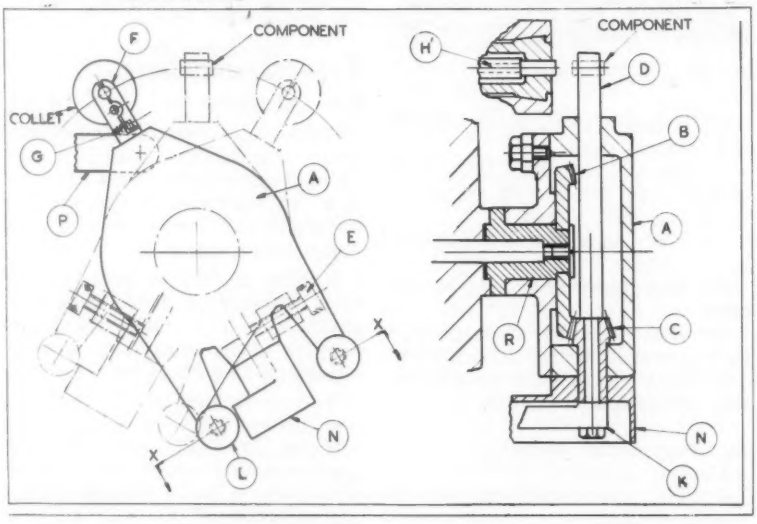


Fig. 1.—Shell as received from the press at A and after the machining on the automatic

Fig. 2.—(below) Transfer mechanism in the initial position and ghosted after moving the shell to the second station. A, fabricated body. B, large bevel gear. C, small bevel gear. D, spindle. E, stops. F, clamping plate. G, spring. H, stop for component with gliding rod J inside. K, lever. L, stops. N, housing. P, link. R, bearing

To facilitate assembly the casing A was made in two parts, one part being bored to provide a location for the bevel gear B. This gear meshed with C, another but smaller bevel, and this wheel rotated the spindle D a half turn while the body was moved 60°. Thus the larger gear B had to turn 120° or $\frac{1}{3}$ of a revolution when gear C made one revolution, a ratio of 3 to 1, and to ensure a correct indexing each time the stops E limited the travel of the housing.

A cam operated link N with the cam arranged in conjunction with the other mechanism caused the housing to pivot on the central bearing, and immediately the shell was pushed into the collet at the second stage the link reversed the action and the arm was again restored to the initial working position. In practice, the arm was held clear of the collet centre line while cutting was proceeding, the halfway distance meant that both collets had the same degree of clearance and as the tools finally withdrew, the link moved again and caused the arm to complete the



movement and remain stationary ready for picking up the next shell.

Another shell F was assembled on arm D and the coil spring G ensured that F acted as a clamp during the picking up and rotation

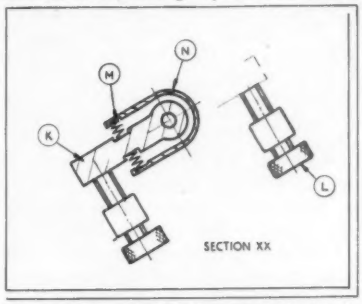


Fig. 3.—Cross section showing stops used when the lower lever is used for returning the mechanism to the original position

of the shell. Only a light pressure was necessary to hold the shell and restricted movement was essential otherwise there would have been difficulty in picking up. A fairly generous lead at the end of the hole where the shell entered was provided and allowed the latter to open the jaw until insertion was complete.

The internally assembled collet parts had two functions—the stop H was attached to the collet and positioned the shell longitudinally, and the hole through this stop allowed another sliding rod J to advance through and eventually eject the piece from the collet into the waiting arm D of the indexing mechanism. Both this rod and the link mentioned earlier were cam operated and timed to fit into the machining cycle.

Once the partially finished shell had been presented in front of a collet, insertion a second time was no problem, especially as the shell was held close to the chuck face. A short movement of the machine slide was sufficient to transfer the part, and another stop inside the collet controlled the finished length.

An alternative method of reversing the spindle is indicated by K in the sketch if the motion is unobtainable by the link mentioned. The latter item is still used as shown, but another movement rotated K in the required direction and so caused the mechanism to stop halfway and then return to the position of the first collet. Stop L limited the degree of travel.

Special Broaching Adaptor

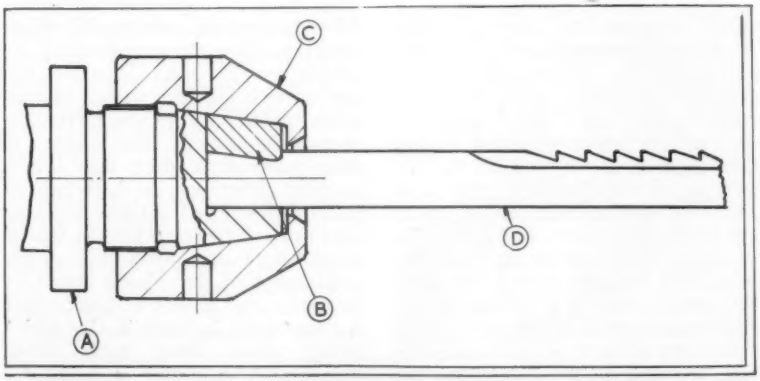
There are often occasions in the design of broaches when the strength of the pulling arrangement is questionable, and though there are various ways of surmounting this weakness, there still occur those isolated examples where the machining of material creates a serious weakening of the broach section, especially as this usually occurs on the sides of a broach.

In an endeavour to overcome this fault (one that can prove very expensive because attempts at brazing a fractured pull are not always successful) an entirely different approach was made and the actual pulling medium on a broach was included on the top surface where the metal is thickest, in preference to the thin cross section so often used for this work.

A simple taper of 8° is sufficient —anything smaller does not seem adequate unless the broach is small, and this dimension gives about $\frac{1}{8}$ in. at the deepest point for a tool $\frac{3}{4}$ in. deep—a taper which, as shown in the sketch does not weaken the end to any marked degree.

A special broach pull A was made to fit the machine ram, and this was slotted to accommodate the insert B; this latter item was shaped to correspond to the curve of the tapered portion. A threaded cap C completed the assembly and this part was case-hardened on the inner taper to withstand the wear arising from repeatedly engaging the insert.

The drawing may give the impression that some time is necessary to load the component in the fixture and to assemble the details prior to the commencement of broaching, but the use of a coarse thread on the pull and cap reduces the time. About 8 or 10 t.p.i. with only some four threads engaging is appropriate, but as the broach pressure is against the taper and this causes the insert to press heavily against the cap, the provision of tommy holes for removal is essential. Finally the broach and insert should not fit the pull too tightly; a clearance of about 0·001 in. is enough to ensure the parts do not become jammed in the pull, and on removing the cap dismantling is quickly performed for the next workpiece.



Broaching adaptor. A, broach pull. (note—end is slotted to receive broach and insert.) B, insert. C, cap holding details together. D, broach—narrow tools used for keyways are the best items for this type of pull.

Skip Loading Device

An arrangement designed by Mr. F. Grundy, Chief Draughtsman of the N.C.B.'s North Western Division, for loading skips at pit-bottom from trunk conveyors, is to be installed at Gresford Colliery, North Wales.

The design involves the use of two mine-cars of similar capacity to the skips. These cars are loaded from the trunk conveyor and then discharged into the skip when it arrives at pit bottom. The cars are mounted on two parallel tracks along which they are propelled by hydraulic driven chain rams. Above the loading positions of the cars a chute is fitted which can traverse across the tracks to feed either car. This chute is traversed hydraulically. Run-of-mine coal from the trunk conveyor is fed into this chute and thence into the appropriate mine-car. The car is driven slowly forward by the chain ram while coal is being fed into it, to ensure even loading. When it is full it is halted in a forward position to await the arrival of the skip and the feed of coal is diverted to the second car by traversing the chute. When the

skip reaches its loading position a proving valve opens allowing the car to move quickly forward to its unloading position above a discharge chute. The drop bottom door of the car operates as the car moves forward, discharging the coal into the skip via the chute.

The design permits the use of any size of mine car from 6 to 15 tons.

Centreless Grinding of Spherical Bearing Rings

Self-aligning ball or roller bearings (Fig. 1) of the type in which the spherically-formed outer ring A fits into an additional seating-ring B have the advantage of maintaining a similar journal capacity to the rigid design, but offer certain manufacturing difficulties when it is desired to grind the outer ring by the centreless process. By reason of the form which has to be ground, they cannot obviously be passed straight through between the wheels of a centreless grinder mounted on a mandrel like rings with an ordinary plain outer diameter which can thus be handled practically like a bar, nor in a continuous stream in which the individual pieces are self-supporting, but on the contrary they have to be individually ground by a plunge-feed cut. The plunge-grinding of such a piece in its turn presents difficulties in maintaining the ring perfectly vertical when supported on an angular workplate between the two opposing wheels.

The manner in which this work is ground entirely automatically on a Scrivener No. 2 controlled cycle machine with special equipment has a number of points of interest which will be dealt with *seriatim*. Fig. 2 is a photograph of one of the these machines so equipped, from which it will be seen that the pieces are fed automatically to the machine by a sloping magazine which can be seen alongside the grinding wheel.

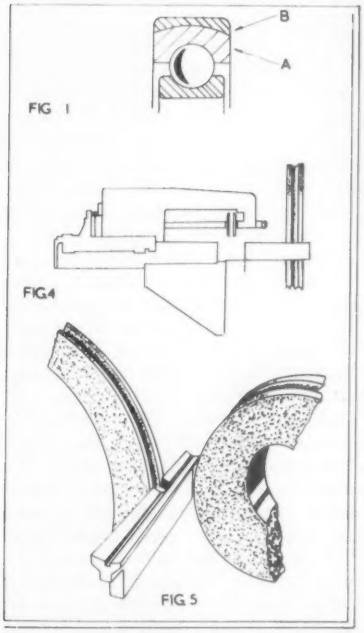


Fig. 1.—Self-aligning bearing. Fig. 4.—Diagram showing push-feed mechanism. Fig. 5.—The workplate.

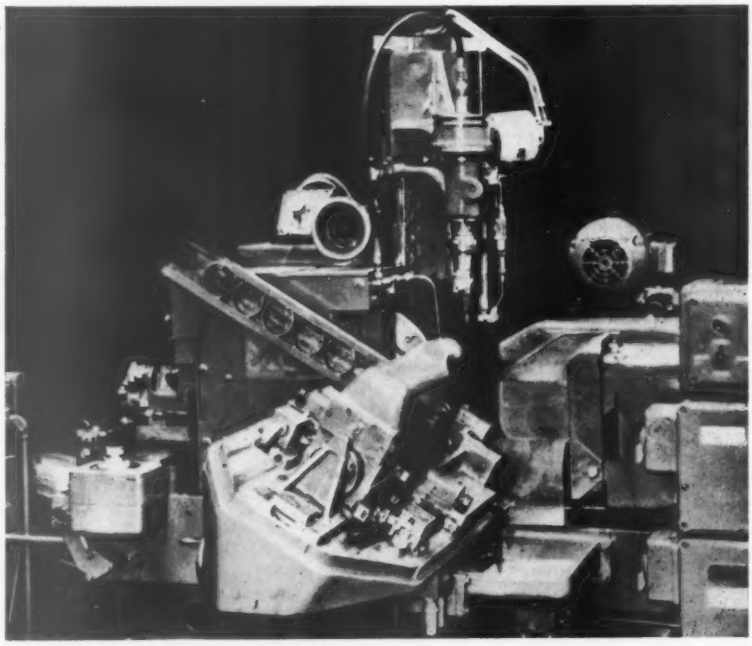


Fig. 2.—Scrivener No. 2 automatic controlled-cycle centreless grinder with equipment for grinding the radiussed diameter of bearing rings (guards removed).

At the commencement of a grinding cycle, the bottom piece in the sloping magazine is dropped into the path of the push-feed mechanism which advances it into the grinding throat between the two wheels of the machine. The difficulty of maintaining such a piece vertically is overcome by employing a pusher with two circular supporting discs between which the piece is housed when it is advanced into the grinding position (Figs. 3 and 4). Once the piece is on the workplate, the pressure on the rear of the two discs is relaxed sufficiently to allow the piece to rotate freely in contact with the grinding wheel.

In place of the normal workplate used for centreless grinding, the machine in this case is equipped with a V-workplate of the type shown by Fig. 5, which in addition to providing a channel for the advance of the piece from the sloping magazine also embodies a second V which serves to locate it for grinding.

The radius truing of both grinding and control wheels is effected hydraulically from the overhead attachment also shown by Fig. 3, all the movements of this attachment being controlled from a Tele-control hand lever to be seen alongside. Movement of the pointer to the right serves to lower the quill between the wheels or to raise it when the operation is finished, and movement of the pointer to the left rotates the diamond and quill. The location of this attachment over the wheels enables either one or both wheels to be radius trued without breaking down or interfering with the set-up, apart naturally from the slight adjustment of the wheels necessary to correct the setting to compensate for the slight increase in size which would result from such wheel dressing. The radius is adjustable from $\frac{3}{4}$ in. to 3 in.

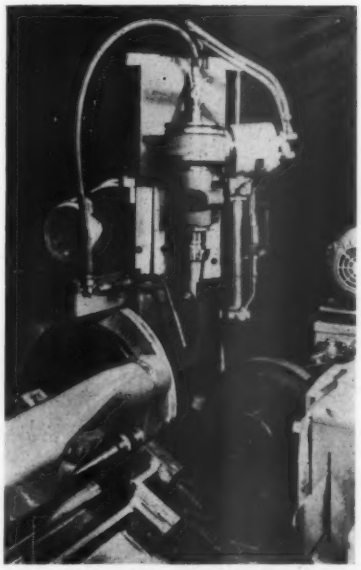


Fig. 3.—The push-feed mechanism (guard removed) and radius-truing attachment

The dressing of the periphery of the wheels on both sides of the radius is covered by the standard hydraulic truing attachments, and the controlled-cycle mechanism (advancing and withdrawing the wheels for the plunge cut in synchronization with the automatic feed attachments) is likewise of the firm's standard design, which is probably too well known to require further description.

With a stock removal of some 0·005 in.–0·006 in., a ring about 3½ in. dia could generally be handled in two passes, each pass taking approximately 15 sec, or about 120 per hour net on a ring for which the roundness has to be within 0·0003 in.

Deburring by Barrelling

One of the six applications for Rotofinish, and perhaps the most important, is deburring. This vital yet rather prosaic and often inordinately costly operation when hand-done is executed in bulk on batches which can vary from six to 500 lb in weight. An example comes from Morgan and Brace Limited, a small firm of precision engineers on the Hirwaun Trading Estate, four miles north of Aberdare. Entirely engaged on sub-contracted machining work for a number of aircraft and instrument manufacturers they employ about 50 mainly skilled machinists in their well-appointed machine shop. They have had a DW 16-16-2, double compartment Rotofinish machine in use for over 18 months, and it is very fully employed in deburring many of the 2100 different items that are machined and pressed in the works. Installed to reduce deburring costs it has now virtually eliminated hand deburring except for a very few items too large for the machine. The components treated range in size from washers as small as 0·005 in. thick by ⅜ in. dia up to formed aluminium chassis of 4 in. square. The materials run the gamut of constructional metals and include copper, brass, phosphor-bronze, mild and stainless steels and aluminium.

Since the one operation only is undertaken only a limited variety of barrelling media is required, and in fact four chip sizes (grinding chip), and three compounds are used; this naturally facilitates operation. Barrelling practice is based on the recommended techniques, but suitably adapted to production exigencies when necessary. An example of adapted procedure was a rush order for the combined deburring and descaling of a large batch of heavily scaled mild steel discs 2 in. dia by ¼ in. thick. This was very successfully achieved without the usual acidic descaling compound and in the short time of 1¼ hr per batch. This, too, was done with a larger batch than the normal 12 lb with a corresponding reduction in the amount of chips, since the shape of this part ensured rapid deburring.

One operator is engaged only part-time on the barrel since with barrelling times of between 45 and 120 or more minutes the machine requires very little attention. All operations are single-stage—although a batch may need prolonged treatment occasionally owing to worn chips or an especially heavy burr—and most of the labour is involved in separating the work from the chips. This is straightforward if it is a case of sorting 40 aluminium chassis but inclined to be more tedious if a mixed batch of small parts. The nominal loadings are 12 lb of components and 56 lb of chips per compartment, but much depends on the shape and size of the work, the amount of impingement which can be tolerated—fast barrelling speeds and heavy loads naturally increase the amount of abrasion—and, of course, the urgency of the operation. The barrel is engaged for 5½ days weekly and, as it is fitted with a time-switch, for an occasional overnight run.

Edge of four in. square aluminium chassis before and after deburring by Roto-finish; the smoothness of contour and uniformity of finish are clearly shown

To detail some of the work, an example is a mild steel valve plate barrelled 40 per compartment with 56 lb of chips and compound 14 K. At about 20 rpm the burrs and any slight corrosion are removed in 90 min, which compares extremely favourably with about 15 min per plate by hand-deburring. The 4 in. square aluminium chassis shown in the illustration which is deburred after forming, is treated in batches of two dozen with compound 100; at 35 rpm these need only 45 min. There is also an aluminium cover barrelled, after forming and riveting, in batches of 30 at 20 rpm. A variety of threaded and slotted mild-steel studs are deburred in 12 lb batches at 20–25 rpm in about an hour, despite the very large burr on some items, while small copper alloy parts are treated for the same time but with compound 255 at 35 to 40 rpm. Tiny stainless steel washers are loaded a few pounds at a time with 4 B chips and tumbled at 25 rpm.

For a capital outlay of less than £500 faster processing has been obtained and a reduction in man-power from the 80% previously engaged to one man employed part-time only, together with a uniformity of finish on components and completely trouble-free operation.

Thermostat Production by Semi-automation

In the new Smiths plant bellows are spun mechanically from "ironed" tubes and and assembly and testing processes are built into a conveyor line. Output is a quarter of a million thermostats a week

NEW types of machines developed by design engineers of Smiths Motor Accessory Division have made possible a 20% rise in the output of thermostats from the Putney Vale factory of K.L.G. Sparking Plugs Limited, part of the S.M.A. group of companies. This increase in output has been more than matched by new orders; thermostats made by the new methods are now standard fittings on a high percentage of British motor vehicles.

The key to this production success story is a machine which, for the first time, enables the all-important metal bellows of thermostats to be spun and fashioned mechanically and to a greater degree of controlled accuracy than was possible by manual methods. Equally important are other machines which deep-draw and "iron" the brass stampings into thin walled tubes, some eighteen inches in length, and it is from these tubes that the bellows are automatically formed.

This new method of drawing enables the tubes to be drawn 10% thinner—at 0·0045 in.—than was possible before, resulting in more sensitive bellows and in consequence a more efficent thermostat.

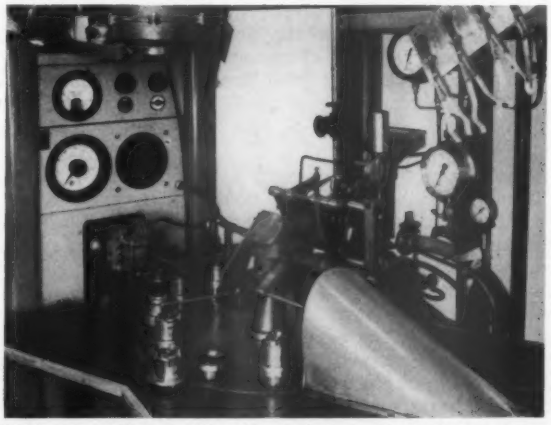
The sequence of preparing the brass from which the bellows are manufactured. Starting with a stamped out disc there follow three cup forming and three tube ironing processes which gradually increase the length of the tube. A feature is the small number of operations performed to produce the required length of tube to thenecessary accuracy of wall thickness

Drawing and ironing of the brass tube from which the bellows are manufactured is performed by machines such as the one illustrated. Capable of producing tubes of 0.0045 in. wall thickness, these machines enable the tubes to be drawn some 10% thinner than was possible before, thereby ensuring a more sensitive bellows resulting in more efficient thermostats

Reduction of the tube drawing process to three draws and three ironing operations, with annealing interposed between stages, is itself a very considerable technical achievement, resulting in uniform wall thickness for each tube to a very accurate degree. Even more remarkable is the substitution of automatic for hand spinning in the forming of the bellows. This highly skilled job was formerly done by operators using hand tools. Now, the new and patented Smiths machine takes the tube and with a "finger" insert pulls it outward against a guide which forms a series of convolutions of predetermined length and diameter. Two bellows are spun, in a matter of seconds, from one length of tube. When each bellows has been formed to a previously calculated size the machine cuts it off automatically.

To match the increased rate of output of bellows made possible by the new methods, semi-automation has been carried to the assembly of the complete thermostats. A conveyor belt carries all the component parts to the operators of each sub-assembly point. The operator removes whichever item is required from the

The forming of the bellows for Smiths thermostats is carried out on this new machine designed by Smiths own engineers. It produces automatically two bellows from one 18 in. length of brass tube, an operation which previously required the services of a highly skilled person who had to spin these bellows by hand



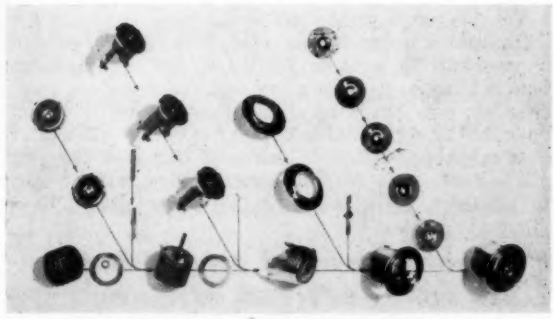
High frequency soldering machines with special sub-assembly rigs similar to the one shown here perform semi-automatically all the soldering operations required for the completed thermostat. This illustration shows the rig and indexing table set up for the attaching of the "bellows plates" and valve stem to the bellows

conveyor and solders it in position by using a specially adapted high frequency soldering unit. This same conveyor ensures that all the components are perfectly clean.

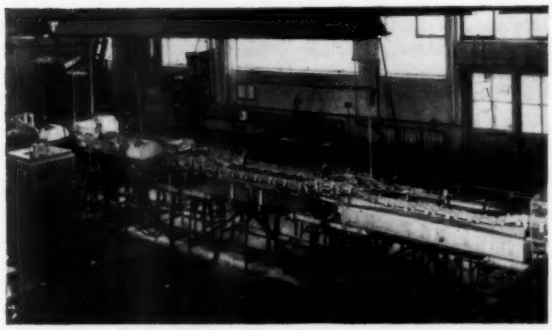
As each item comes away from the press or form tool it is attached to the conveyor, and *en route* to the sub-assembly point, is passed through an electrolytic cleaning process.

From the moment the bellows come off their forming machine to the completion of the actual thermostat, very little "handling" of the components is evident; the assembly cycle being that the bellows are first spin dried to remove surplus moisture and then annealed to relieve manufacturing stresses. The ends are cleaned

The overhead conveyor system which supplies the component parts to the operators seated beside it. The operator on the left is just removing from the conveyor the next component to be assembled. The next operator is assembling the valve seating to the bracket and swageing the patented "T-slot" fixing, whilst on the right the thermostat valve seating is being machined and the valve assembled



The component parts which make a complete thermostat. The arrows indicate the order in which components are assembled



The conveyorised calibrating rig. On the left is the elctronic control unit which maintains the temperature of the calibrating tanks to within ± 1°C of the calibration temperature. The nearly completed thermostat is passed through these tanks and whilst in transit the thermostat valve is finally soldered in place and the then completed unit is tested and its calibration checked before its eventual ejection and visual inspection

and tinned on one of the many different rigs attached to the various high frequency soldering units prior to having the "bellows plates" and valve stem soldered in position.

As soon as this operation is completed the unit so far assembled is ejected automatically from this rig and passed by conveyor belt to the next sub-assembly stage which is the fixing of the carrying bracket to the

bellows. By means of an indexing table attached to the high frequency soldering machine the bracket is first soldered in position then a solution of methylated spirits and water (the thermostat controlling fluid) is injected through a small hole in the bracket and into the bellows. Air is then evacuated from the bellows via this hole and whilst still under vacuum a taper pin is fed into the hole and pushed home prior to final sealing by soldering the pin in place.

Next stage is the attaching of the valve seating to the bracket and this is achieved by a patented "T slot" fixing. Whilst in position the seating is trimmed to its correct size and the valve is assembled. The completed unit is now placed on a special "conveyorized" calibrating rig where it passes through the water-filled calibration tanks, the temperatures of which are electronically controlled to ± 1° C. During passage through these tanks the thermostat valve is finally soldered in position whilst still in water by the last of the many high frequency soldering machines used in this method of thermostat manufacture.

Testing, too, is performed on this same conveyor. The thermostat is stressed to be beyond its normal operating temperature by virtually boiling it. Its actual calibration is checked to within the required tolerance and a check is also made to ensure that the valve is fully open 15° C above its calibrated opening temperature as a safety precaution. From here the units are automatically ejected, visually inspected and packed ready for despatch at the rate of 25,000 per week.

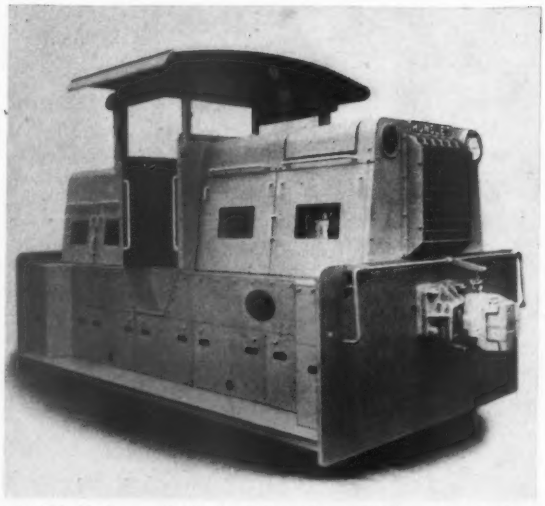
Power-operated Down-feed Unit for Vertical Miller

The Herbert No. 47V vertical milling machine has proved extremely suitable for light precision operations and heavy cutting with carbides on materials ranging from aluminium to high-tensile steels. A wide speed range, a comprehensive range of automatic feeds to longitudinal and transverse motions associated with an extremely sturdy spindle and bed ensures maximum efficiency within its capacity of 48 in. × 16 in. × 23 in. (1219 × 406 × 584 m/m).

To increase its field of application the spindle head of the Herbert No. 47V vertical milling machine can now be fitted with an automatic power down-feed unit. This new unit permits any combination of holes in the vertical plane and at five levels, to be drilled and accurately bored during the same setting as for the milling operations. This simplifies a fundamental machining practice, common in most toolrooms, of holding close tolerances between surfaces normally machined in two operations on different machines and requiring considerable skill in re-setting.

The indexing barrel, having five adjustable screw stops for milling up to five levels at one setting, is used to trip the down-feed of the spindle. Three rates of down-feed are provided—88, 165 and 330 cuts per in. A large micrometer dial, if set to zero at the commencement of cut, will register the depth of hole drilled or bored. The feed shaft is driven by a V-belt and reduction gearing from the spindle, thus maintaining correct ratio between the speed and feed.

The machine which has a capacity of 48 × 16 × 23 in. is manufactured by Alfred Herbert Limited, Coventry.



Hunslet 71 hp Yardmaster diesel-hydraulic locomotive supplied for service in Southern Rhodesia. This locomotive is powered by a Gardner 4LW diesel engine derated to 71 hp to suit site conditions

Shunter Driving from the Side Platforms to Reduce Fatigue

A new approach to industrial shunting locomotive design is to be found in the Hunslet Yardmaster, a 13–15 ton 71 bhp industrial locomotive which can be handled by finger controls in easy reach from the side running platforms. The object is to reduce the persistent climbing entailed when the driver performs shunting duties such as point changing or wagon coupling. Normal seated driving positions are provided either side of the central cab and the field of vision is greatly improved by the fitting of one-piece windows at the front and rear.

The locomotive is powered by a Gardner 4LW or Dorman 4LB water cooled diesel engine developing 71 bhp at 1700 rpm and is fitted with electric starting. Transmission from the engine is through Layrub couplings to the Hunslet single stage torque converter unit and two speed constant mesh gearbox. The gearbox and torque converter unit are manufactured as a single assembly to ensure that perfect alignment is maintained. Special attention has been paid to the simplification of the gear control, the selector lever with finger-pressure sensitivity hydraulically controls gear clutch selection. These clutches are of the multi-plate type having sintered metal face linings for long life.

The Westinghouse straight air brake and a powerful screw hand brake operate through cast iron brake blocks on all four wheels. The air supply is maintained by a Reavell T.B.C.12 compressor. Gravity feed sanding gear with four sandboxes is provided mainly to assist braking as the torque converter enables extremely good adhesion to be obtained even under adverse rail conditions.

The Yardmaster is built by The Hunslet Engine Company Limited, 125 Jack Lane, Leeds 10 for metre, 3 ft 6 in. and 4 ft 8½ in. gauge. The 2 ft 9 in. dia coupled wheels and motion are totally enclosed by the low platforms which extend to a full distance over the buffer beams of 13 ft 3½ in. The two speeds in either direction are 5 and 10 mph and the maximum tractive effort in 1st gear is 8000 or 10,200 lb depending on the weight.

A general view taken from the power station roof of the new board mill. In the foreground is the salle or finishing department with the other sections of the main production building, over a fifth of a mile long, behind. Thatcham village is in the background

The wet end of the board machine. On the left of the picture is the Harland drive control desk. The machine produces mainly folding box board, 110 in. wide, at a maximum speed of 600 ft per min

World's Newest Board Mill

One of the most advanced paper board mills has recently been brought into production by the Reed Paper Group. Built at the cost of £5,000,000 *the mill is entirely self-contained with its own power station, extensive workshops, raw materials building, finishing department and water treatment plant in addition to the main production installations. The board machine incorporates a high degree of instrumentation and several unique features of design. At peak capacity it produces in a day a continuous highway of board* 110 *in. wide and* 160 *miles long*

THE first complete board mill to be built in Britain for 25 years has started production at Colthrop Board and Paper Mills Limited, Thatcham, Berks, three and a half years after the order for the board machine had been placed. This £5,000,000 project of The Reed Paper Group is entirely self-contained on a 40-acre site, including storage buildings, workshops, water services, effluent treatment plant, power station, messing facilities, and transport services in addition to the main production plant.

Stock preparation

Hydrapulpers prepare the stock for the four separate systems which are in use and are arranged for interchange of duties in an emergency.

The 'middles' system is served by a 20-ft dia continuous extraction hydrapulper which is mainly fed by a heavy duty slat conveyor rising from ground-floor level to discharge into the tub. A 16-ft dia continuous extraction hydrapulper is used for the preparation of the 'underliner' stock and this, together with the 20-ft hydrapulper, has steam injection to increase the rate of disintegration. Both units are fitted with junk removers and raggers.

Two 14-ft dia batch type hydrapulpers are used for the preparation of the 'liner' and 'backs' stocks, the former being pumped to a duo-cycling system, whilst in the case of the latter, the stock is pumped either to a cleaning system or direct to the unrefined stock chest.

The tops of all hydrapulper tubs are level with the first floor which forms a platform at the end of the building and the spacious area allows a squeeze-clamp electric truck to transport and stack bales of wastepaper or pulp from weighing machines to the hydrapulpers.

Hoods are provided over each hydrapulper for cleanliness and also to eliminate unpleasant conditions.

Adjacent to each hydrapulper at first-floor level there is a control station for the drive and pump motors and on each panel there is a master control circuit switch operated by a Castell lock which allows a person to enter a hydrapulper tub in safety after first having removed the key from the lock.

Stock cleaning in the case of the 'middles' system is carried out by a battery of Vickery Jumbo Dirtecs which remove heavy materials and the stock discharges to four Black-Clawson classifiners which in turn reject the lighter impurities. The accepted stock is passed to five thickeners or deckers manufactured by Watford Engineering Company Limited, where the consistency is raised from 0·8% to about 3½%, and the whitewater extracted in this process is returned to the 20-ft hydrapulper regulating box to dilute the stock prior to delivery to the Dirtecs.

The rejects from the classifiners pass to a disintegrator pump, which is a small steep angled conical refiner, and thence to a Black-Clawson Selectrap from which the accepted stock is passed back into the system for further treatment.

The 'underliner' stock, after initial preparation in the 16-ft dia hydrapulper, can either be pumped direct to the unrefined stock chest or it can be diluted to 0·8% consistency for cleaning by Jumbo Dirtecs and then thickened as for the 'middles' stock.

A general view looking down on the west end of the Harland drive annexe. In the immediate foreground are motors driving the primary presses. To the left is a multi-motor contactor switchboard used for the control of machine wet-end auxiliaries

A view of part of the stacked dryers, the calenders and rewinder at the dry end of the machine. There are 130 cylinder dryers in eight vertical stacks

The 'backs' stock is pumped from the 14-ft dia batch hydrapulper to a storage chest from which it can be treated by a Black-Clawson 4B hydrafiner driven by a Mather & Platt 240 hp motor at 1440 rpm, or else the stock can be passed direct to the refiners. The 4B hydrafiner is fitted with Duotrol automatic plug control and the stock can be circulated through the hydrafiner for a predetermined number of passes at a pre-set drive motor electrical loading before being pumped to the refiners.

This hydrafiner and its associated chest and pump are on the ground floor with the control desk at first floor level. The desk incorporates all the motor starters, a recording ammeter for the main drive and chest depth recorders, as well as a mimic diagram which gives visible indication of the operating position of all the plant controls.

A complete Black-Clawson hydrafiner duo-cycling system with a central control desk provides the main treatment for the 'liner' stock which is first prepared in the 14-ft dia batch type hydrapulper where a weighed amount of pulp is treated with a metered quantity of water. The plant consists of three No. 6 size hydrafiners each driven by Mather & Platt 350 hp motors at 490 rpm, all situated on the ground floor.

In addition, there is a duo-cycling chest and a blending chest, both being vertical cylindrical tile-lined units of cast iron sectional construction by H. J. & A. Coulthurst Limited, with the tiling by James Scott & Son (Aberdeen) Limited.

The duo-cycling chest is divided by a vertical midfeather and at the start of each batch treatment, one half of the chest is filled with stock at 5½% consistency.

A circulating pump is connected through a valved manifold to each half of the duo-cycling chest and the passes are effected by the pump emptying one half of the chest and delivering through the hydrafiners to fill the other half. After the requisite number of passes the stock is automatically delivered to the blending chest and a metered quantity of water is added to reduce the consistency to 3% or 3½%. From here the stock is pumped to either one or other of the two 'liner' unrefined chests.

The plate type valves for this duo-cycling system were supplied by Black-Clawson—those essential to the automatic action of the system are electrically controlled and pneumatically operated, while the infrequently used hand operated valves are fitted with limit switches to provide remote indication of the valve positioning on the control desk mimic.

On the ground-floor of the preparatory plant building there are eleven reinforced concrete tile lined chests which were constructed by James Scott & Son (Aberdeen) Limited, nine of these are agitated by Black-Clawson Class-L agitators and two by propeller type agitators. In order to conserve heat and improve working conditions, all the chests are totally enclosed and are situated so that the pipelines to and from the plant above are as short as possible. All the stock pumps are of Black-Clawson manufacture, direct coupled to Mather & Platt motors. Wherever possible, pumps and motors have been standardized to reduce the holding of spare parts.

The final treatment of the four different types of stock is by refining and there are seven Walmsley No. 4 size conical refiners each direct coupled to a Mather & Platt 250 hp motor and driven at 365 rpm.

The stocks are delivered to a stainless steel compartmented distribution headbox at high level from which there is an individual connexion to each refiner and this allows a wide variation in the use of these refiners, particularly as they are arranged for operation singly or in series.

The seven refiners are raised on a platform above first floor level and discharge into stainless steel troughs running along the front of the platform with connections from these troughs into the various machine chests below.

The refiners each have a motor control station comprising 'stop' and 'start' buttons and an ammeter, adjacent to the hand wheel operating the moving shell, whilst the main Igranic contactor switchgear has recording ammeters to give an overall indication of the stock treatment.

In front of the refiner outlet troughs there is a large Foxboro-Yoxall instrument panel incorporating chest depth level recorders and consistency regulator recorders, and a control desk for all the pump and agitator motors related to the refining system. The compact arrangement allows quick and easy control of the refining process.

Consistency control equipment, supplied by Foxboro-

Yoxall Limited, provides control and recorders for all four systems before and after refining and this arrangement gives close regulation over a wide range. In addition, there are consistency indicators for the stock after the 'middles' and 'underlines' thickneners.

Close control of gland sealing water, etc., to avoid excessive stock dilution is obtained by the extensive use of Rotameters in all sealing or purge water pipelines.

In the preparatory plant special attention has been paid to heating and ventilating the building, particularly as hot stock is likely to cause unpleasant conditions. Carrier-Ross have supplied air heaters with input fans as well a extraction fans, producing comfortable working conditions.

A dissolving plant for aluminium sulphate blocks, situated at ground-floor level, comprises three reinforced concrete asphalt lined tanks which are served by an overhead electric crane. The concentrated solution is delivered to high level dilution and storage tanks on the second-floor by acid proof pumps whilst polythene piping is used throughout. An automatic plant emulsifies concentrated fortified rosin size with water and the resulting 5% solution is pumped to high level storage tanks. Facilities are provided for the continuous addition, by metering, of alum and size solutions to various points in the stock systems.

Board machine

The machine house is 435 ft long × 75 ft wide (including the drive annexe) × 62 ft overall height. The drive annexe runs the full length of the machine house and has an intermediate floor for the large ventilation plant. The machine headbox and screens are housed in an area to the side of the machine house at the western end.

The basement type board machine constructed by Walmsleys (Bury) Limited, and their associate Walker Brothers (Wigan) Limited, has a trimmed width of 110 in. and is designed for a maximum speed of 600 fpm. A number of special design features have been incorporated at the request of Colthrop, many details having been developed by their engineering department.

The four stocks are delivered to a stainless steel compartmented headbox directly above eight size 3A dual-drive bird screens. The diluted stock discharges from the bird screens into separate stainless steel outlet boxes and then to conical mixing boxes for de-aeration and further mixing with whitewater.

The stock finally flows from the conical mixing boxes to the machine vat section through stainless steel or mild steel Lithcote lined piping into stainless steel flow spreaders connected to the first up-flow passage of each vat. The vat section comprises eight 48 in. dia cylinder moulds and vats—six of the contraflow type, and two so designed that they can be used for contraflow or uniflow operation. Four of the cylinder moulds are driven and the remainder are prepared to receive drives.

The eight vats have cast iron box section sides giving a clean and neat appearance whilst an efficient system of mould air extraction has been incorporated in the construction of the vats, the fan and ducting being supplied by the Carrier-Ross Engineering Company Limited. Each vat is provided with a 20 in. dia rubber covered top couch roll mounted on adjustable arms carried from the main framing which stands on the vat sides.

The vat draught pumps at ground-floor level are direct coupled to variable speed d.c. motors, supplied by Mather & Platt Limited. The direct current supply is obtained from a 400 kW Hackbridge & Hewittic mercury arc rectifier. Remote speed control for the pumps is provided at the front of each vat, and an indication of the speed of each motor is given on a composite panel at the end of the machine house.

Following the vat section there is a 28 in. dia extractor roll and then a 30¼ in. dia suction return roll leading to five primary presses mounted on fabricated steel box section frames located immediately above the vats. In the fourth primary press position there is a suction press; but all five positions are so designed with cavity framing that a suction press can be mounted in any one of these.

The main press section comprises a first plain press, a second suction press and then a third plain press, all having 26 in. dia rolls with granite top rolls in each position. Vickery conditioners are used on the two press felts and suction squeeze rolls assist the cleaning of the top and bottom making felts, while motor-operated felt stretching gear is provided for all the felts.

All press loading, with the exception of the mould couch rolls, is by means of pneumatic cylinders controlled by independent pressure regulators and the control panels, which include load gauges, are mounted on the front framing adjacent to each press. The framing throughout the machine is of box section.

In front of the vat and press sections at first-floor level an acid-proof tile floor has been laid and this also provides a non-slip surface.

Nash type vacuum pumps for the suction rolls, conditioners and suction boxes are at ground-floor level and each is complete with a receiver separator, extraction pump, discharge separator and silencer. The water seal troughs for each discharge separator are piped together and a small pump re-circulates the gland and priming water to the vacuum pumps, while a ball float controlled freshwater make-up connexion is provided.

The backwater 'pits' below the vat section are in the form of reinforced concrete tanks standing on the ground-floor. The 'liner' and 'middles' backwater pumping units removing water from these tanks are of Mather & Platt manufacture and are automatically controlled by the water level. The connexions from the tanks or 'pits' for the various shower pumps are positioned to ensure constant supplies of water, and strainer boxes are fitted in the pump suctions. As a safeguard, a dump and overflow tank is provided and this is emptied by two pumps which are arranged to start and stop at predetermined water levels.

Long stroke hydraulic oscillators are fitted to all mould and felt shower pipes, with short stroke units for the press roll and pre-drying cylinder doctors (the latter type can only operate when the machine is running and therefore damage to roll or cylinder surfaces is avoided).

The pre-dryer section comprises 26 steam-heated drying cylinders of 5 ft dia arranged horizontally in two tiers with a Ross-Grewin vapour absorption system. The whole section is covered by a dryer hood with extraction fans discharging to exhaust towers rising above the main roof level.

There are 130 steam-heated drying cylinders of 3 ft 6 in. dia in the main dryer section, arranged in eight vertical stacks. A standard cross tube type of vapour absorption system using fairly high velocity hot air is installed on the stack dryers. A steam-heated smoothing

press having 24 in. dia chilled iron rolls is located between the second and third vertical stacks.

Above the stacks there is a false ceiling of enamelled steel heated by a flow of hot air, and extraction fans in the wall behind the dryers remove the humid air at high level.

The vapour absorption, heating and ventilating systems, supplied by the Carrier-Ross Engineering Company Limited, are installed above the drive annexe. Air is drawn in mainly at one end of the upper part of the annexe which acts as a large duct to feed the various fans. The main heating and ventilation at each end of the machine house at high level to prevent condensation is effected through air inlet ducts formed between the roof beams, with diffusion through the flat concrete ceiling, whilst extraction fans are provided in the end wall.

Steam to all air heaters is thermostatically controlled and, in order to economize in steam consumption, provision is made for the use of re-circulated air at certain points.

The pre-dryer and stack dryer cylinder gears are provided with robust mesh type guards supplied by F. W. Potter & Soar Limited, and a semi-automatic system of gear lubrication, supplied by Farvalube Limited, is working successfully. The back and front-side bearings on all the drying cylinders and the calenders are continuously lubricated by a circulating oil system which also includes a DeLaval purifier, an oil cooler and duel circulating pumps.

The steam circulating and condensate system for the drying cylinders was supplied by Reiss Engineering Company Limited, and the steam pressure is regulated by an Arca valve having a control panel at first-floor level, incorporating a steam flow recorder and pressure gauges for the steam in the various sections.

Flash steam from the lowest pressure section is passed to air heaters and for the whole system there is a large condensate tank with duplicate pumps for the return of the condensate to the boiler house some 900-ft away.

Two finishing calenders are installed, each having seven rolls, and, with the exception of the bottom rolls, all are bored for steam heating. Vickery doctors are fitted to all rolls and five rolls on the first stack are fitted with water doctors. The load application to the top roll bearings is by levers, vertical rods and weights, whereas the rolls can be lifted individually or collectively by motor operation. The machine reel-up is of the double arm drum type designed to wind reels up to 76 in. dia.

The machine is driven by a Harland interlocked sectional electric drive having an operating speed range of 100 to 600 ft per min with a crawl speed of about 30 ft per min.

There are twenty-five separate driving units, each comprising a motor and gearbox on a combination bedplate and ranging from five to 80 hp output. The driving shafts are all fitted with flexible couplings and connect to the machine through special openings in the annexe wall.

The spacious drive annexe runs the length of the machine and houses, in addition to the Harland drive, most of the contactor switchgear for the pump and fan drive motors. There are also two 5-ton capacity overhead hand cranes, and the whole annexe is kept under a slight air pressure to exclude dust and the humid atmosphere from the machine house.

A 775 hp synchronous induction motor drives the main 500 kW generator and a flat-back open type circuit breaker switchboard supplies the section drive motors.

A control desk is situated in the machine house in front of the main presses and at each section of the machine there is a small control panel for the particular section motor. A visible and audible system is provided in front of the machine to give warning of any failure of a vital part of the drive or special ancillary equipment.

The board substance on the machine is continuously checked by means of Baldwin Atomat radiation gauges installed before the first pre-dryer and after the calenders. At each position there are three measuring heads across the width of the machine and recording instruments give a clear indication of any change in basic weight, enabling immediate correction to be made.

The machine is served by three Vaughan electric overhead double-crab cranes.

A Masson slitter and re-winder is at the end of the machine at first-floor level and is fitted with a hydraulic finished reel ejector followed by a special table, adjustable in height, and an Avery weighing machine with a platform flush with the floor and capable of weighing full width reels. The drive for the Masson winder consists of a Hackbridge & Hewittic Velotrol type grid controlled mercury arc rectifier supplying a variable speed d.c. Mather & Platt motor giving an operating speed range of 200 to 1600 ft per min.

The pair of unwind stands are fitted with motor driven barring gear for rotating the parent reel when feeding the winder and also motor driven lateral adjustment for trim control, both these motor drives being operated from the winder control desk.

Below the winder at ground-floor level there is a broke beater supplied by West End Engine Works Limited, and driven by a 150 hp Mather & Platt motor. This beater is situated in line with the machine and can deal with all 'broke' which arises, including the trim from the winder above.

Reels are finally transferred from the machine or the winder by means of a special motor driven trolley to a balcony projecting into the salle building whence they are handled by an overhead travelling crane.

The salle, or finishing and storage building, has three crane bays, one of which is known as the service bay into which the balcony projects from the machine house first-floor. The overhead electric travelling crane in this bay serves a Masson duplex supercutter, a Masson simplex cutter and a small Thrissell slitter and re-winder, as well as transferring reels for storage prior to despatch. The other two crane bays are used for storage, handling and despatch of finished reels. There is a fourth bay which has no crane, in which the Masson cutter stands, and this bay is used for sheet packing, storage and despatch.

The Masson duplex supercutter deals with full width machine reels and has a speed range of 150 to 700 ft per min, being provided with two pairs of unwind stands similar in every respect to those installed with the Masson winder. An automatic layboy with hydraulic stack equalizing device collects the sheets from this cutter and the trimmings are pneumatically conveyed to the broke beater.

Extensive use is made of pallets and stillages, with electric trucks, for the storage and despatch of sheets. A loading dock constructed above ground level with

a sloping approach ot correct gradient for the electric trucks, is used for loading sheets on to vehicles.

At the eastern end of the building there are five large doorways to admit vehicles for loading, with electrically operated doors supplied by Bolton Gate Company Limited.

Power station

The power station is completely separate from the mill buildings and the 21 in. dia process steam supply main is carried across to the mill on an overhead gantry which also carries the return condensate pipeline and the electric cables. The building covers a ground area of approximately 12,000 sq ft and is divided into three main sections, turbine house, boiler house and water treatment annexe.

The fuel handling plant includes a Strachan & Henshaw Rotaside wagon tippler for handling railway trucks of 10 to 25-ton capacity, discharging into an underground receiving hopper. The open side of this hopper is ramped for the discharge of end tipping road vehicles. The discharge from the hopper is on to a 24 in. wide belt conveyor and a Westminster type belt weigher is installed. A second inclined conveyor, fed by the first one, carries fuel to the bunkers where a travelling belt tripper is arranged to oscillate over the length of each bunker to spread the fuel evenly.

The feedwater treatment plant supplied by Neckar Water Softener Company Limited comprises a single lime reaction tank in which the raw water is pre-treated by hot lime process; three pressure filters and three zeolite tanks provide after treatment to give zero hardness. The whole feedwater supply to the feed pumps is passed through a Weir de-aerator.

Two water tube boilers are installed, each having a maximum continuous duty of 88,500 lb steam per hour at 525 psi and 780° F at the superheater outlet. The boilers are of the three drum vertical tube type with integral steam receiver between the boiler drum and the superheater inlet. They are of International Combustion Limited manufacture, stoker fired and each with integral superheater, economizer and draught plant. The furnaces are water cooled on the front and side walls.

The main electrical generating equipment is a direct coupled 3000 rpm, turbine driven alternator set of the pass-out condensing type with an output of 7500 kW supplied by Metropolitan-Vickers Electrical Company Limited. The alternator generates at 11,000 volts and can be paralleled with an incoming supply also at 11,000 volts from the Southern Electricity Board distribution network. The pass-out steam pressure from the turbine is manually adjustable from 20 to 60 psi to suit the mill production requirements.

The main switchgear located at first-floor level in the turbine house is 250 MVA, QA type of British Thomson-Houston manufacture and from this an 11,000 volt ring main is connected for the mill supplies.

There are two sub-stations in the mill situated as near as possible to the load centres, and at each of these there are two 2000 kVA transformers interconnecting the 11,000 volt and 415 volt switchboards. The main 415 volt type 'AJ' circuit breakers are of British Thomson-Houston manufacture and these supply the various multi-motor contactor switchboards supplied by Igranic Electric Company Limited.

Power factor correction is generally achieved by the installation of Ferranti capacitors connected in a number of motor circuits and also by adjustment of the 775 hp synchronous induction motor of the Harland drive.

A medium voltage ring main supplies lighting distribution boards, low voltage socket outlet and welding connexion points which are distributed around the entire mill. The 'welding connexion points' are available for use by industrial vacuum cleaners and portable high pressure pumps.

The mill lighting is of a very high standard and particular care has been taken since there is no natural lighting in the main sections of the mill. In the areas where height for fittings is in the region of 40 ft, the blended type of lighting is used, while fluorescent lighting is used in the other areas. Full scale use of colour on all plant makes the interior of the mill refreshingly bright and attractive. Strong accents are provided by the various large items of machinery and switchgear which are painted in bold colours, while the surrounding pipework conforms, wherever possible, to the British Standards Specification for Pipe Identification, and recognition colour charts are placed at various work centres.

The effluent from the mill is passed to a clarification plant consisting of two 50 ft dia Dorr Clariflocculator tanks with rotating scraper mechanism, the plant being capable of handling 600,000 gal per day. The clarified water is then pumped to percolating filters for further treatment before being returned to the Kennet and Avon canal.

In addition to the main clarification plant there is a micro-strainer manufactured by Glenfield & Kennedy Limited, which has been specially installed to treat water from the top and bottom felt whipper showers on the machine.

A single-storey workshop building is situated along the south wall of the machine house. Centred on a large stores, there are well equipped workshops for fitters, electricians, carpenters, blacksmiths and instrument mechanics. A variety of modern machine tools and testing equipment is installed and any normal maintenance or development work can be undertaken.

Graphite Lubricator Reduces Railway Tyre Wear

The wear of railway wheel tyre flanges which occurs when locomotive and rolling stock negotiate sharp curves presents a problem of constant maintenance and expense. Where the wear has been excessive the tyre requires machining to restore the correct flange profile and finally after repeated machining a new tyre needs fitting. Tyre wear can be greatly reduced either by fitting tyre-watering gear or more simply by some form of tyre flange lubricator. A new method for lubricating the wheel flanges of both trains and travelling cranes, utilizing a graphite rod has been developed by The Morgan Crucible Company Limited, Battersea Church Road, London SW11. The Morganite wheel flange lubricating rod consists of a soft graphite material encased in a harder carbon tube. The lubricant is applied only to the wheel flanges and being solid cannot run or 'creep' on to the tread and cause skidding. The rod itself may be carried in a simple holder, thus keeping the rod constantly applied to the flange, and making the lubricant available while the vehicle is in motion.

High Energy Steady State Injection into Thermonuclear Devices

The Luce Ignition Scheme

IN a talk given before the American Physical Society in Washington, D.C., U.S.A., on May 2, 1958, Dr. Albert Simon of Oak Ridge National Laboratory dealt with progress in the four basic methods undertaken in the United States of controlling the thermonuclear reaction. What he said represents the first significant account ever made of the unusual approach adopted by the scientists at this United States Atomic Energy Commission laboratory, operated by the Union Carbide and Carbon Corporation.

Dr. Simon dealt mainly with the concepts involved in a particular field of thermonuclear research and not with the experimental details. He said that in the case of the Stellarator (as well as the Pinch) one started with a cold plasma and attempted to heat it by various combinations of joule heating and magnetic squeezing. The Livermore method utilized energetic ions to begin with and trapped them by use of time-rising magnetic fields. The heating of a cold plasma might be quite difficult since there might be a tendency for instabilities to develop during these processes. On the other hand, trapping of energetic ions by time-rising fields had its own difficulties, owing to the necessity of trapping a very fast particle in a finite volume. This required rapidly rising fields and made difficult the accumulation of an appreciable plasma in the volume. The Oak Ridge approach attempted to evade the time-rising field feature by a method which allowed the steady state injection of hot ions into a d.c. field.

The method essentially was the injection of an energetic molecular ion across a magnetic field. If, now, one caused this molecule to dissociate near the extremity of its orbit, the resultant ion would then have half the momentum of the original molecule, and hence half the radius of curvature in the field and it would not return to strike the source. The scheme is illustrated in Fig. 1.

This suggestion was first made by John Luce in 1955. It was also suggested independently by Herbert York at about the same time and had since appeared in the unclassified literature in a paper by Moon as a scheme for injection into cyclotrons. This was called the Luce Ignition Scheme for a deeper reason than the suggestion itself, however. The method meant little unless one actually had a means of dissociating these molecular ions with high efficiency and in the right regions. John Luce in his research on various forms of gaseous discharges had discovered an unusual type of arc discharge which had just this property. The combination of an arc discharge of this type, together with a confining d.c. magnetic field and high energy molecular injection, then constituted a class of thermonuclear experiments which became designated as d.c.x. (for d.c. experiments).

The detailed structure of the arc discharge and the reason for its high dissociation efficiency were as yet imperfectly understood. "Let us, therefore", said Dr. Simon, "simply accept the existence of this arc and its ability to dissociate a large fraction of the molecular beam as an empirical fact."

For illustration, he considered injection and trapping in a mirror geometry. This was the easiest way to use the Luce Ignition Scheme, although it was possible to envision its use in a Stellarator geometry or even in the Pinch. A simple system is shown in Fig. 2. The arc was run through the mirrors. The energetic deuterium molecular ions were injected across the field and partially dissociated and trapped as shown.

What happened to these trapped ions? Ordinarily, they would simply circulate until a charge exchange occurred with one of the neutral gas atoms in the system. When this occurred, the fast ion became a fast neutral and was immediately lost from the system. There remained a cold ion. Hence, this provided an excellent (and unwelcome) mechanism for draining the input energy out of the device. The charge exchange would occur long before any appreciable energy loss, deflexion, or nuclear reaction had occurred. No further progress could be made until the neutral background was greatly reduced. For example, at 300 kilovolts,

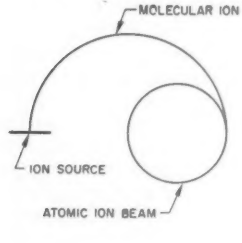


Fig. 1.—Trapping the ion beam. A molecule injected across a magnetic field and caused to dissociate near the extremity of its orbit produces an ion of half the momentum and hence half the radius of curvature

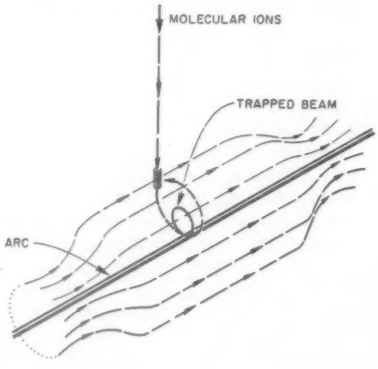


Fig. 2 (left).—An arc discharge in a confining magnetic field provides the means of dissociating the molecular ions and thus producing the trapped beam

$$I_{CRIT} = \frac{\sigma_{cx}}{\sigma_i + \sigma_{cx}} I_0$$

for $S \simeq 6 \times 10^3\ cm^2$ and $E_+ = 300$ kev

I_{CRIT}	P
800 ma	10^{-5} mm Hg
80	10^{-6}
8	10^{-7}

Fig. 3 (above).—Formula for critical trapped current with some typical burnout figures

which was well beyond the charge exchange peak, the charge exchange cross section was still 2×10^{-18} cm^2 in deuterium gas, while the Coulomb deflexion cross section was about 10^{-22} cm^2. Hence, the neutral pressure had to be reduced to less than one part in 10^5 of the ion background before a plasma could begin to form. By direct pumping this could require an initial pressure of the order of 10^{-9} mm of mercury or less. Fortunately, the trapped beam itself helped to destroy the neutral gas in the plasma region.

At 300 kilovolts, for example, the ionization cross section was 4×10^{-17} cm^2. Hence, 20 neutral atoms were ionized by a fast ion before it suffered a charge exchange. There is a critical point at which the neutral atoms were being destroyed just as fast as they were flooding in from the vacuum manifold. Once this point was passed, the ions got ahead of the neutrals. The plasma built up, hence burning out additional neutrals and the system cleaned itself up in short order. Dr. Simon called this critical point "burnout". In terms of injected current, we had the formula given in Fig. 3. Here I_{crit} is the critical trapped current, I_0 the total neutral current in the plasma region. The ratio of cross sections indicated the fraction of ions destroyed per neutral destroyed. Note that the critical current varied linearly with the pressure.

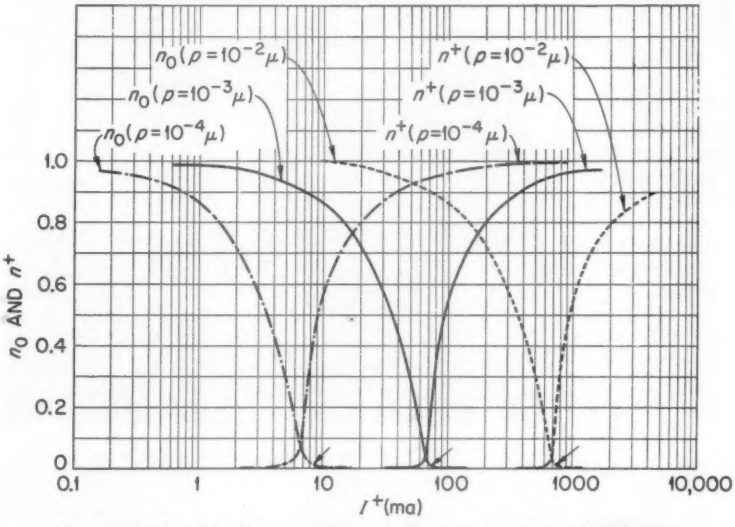


Fig. 4.—Solutions obtained with analogue computer. The arrows indicate critical current value.

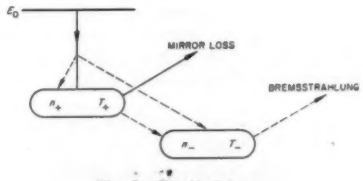


Fig. 5.—The ideal d.c.x.

Some typical values of the burnout current are shown at the bottom half of the figure. These values are for a spherical plasma volume whose radius is equal to that of a 300 kilovolt deuteron in a field of about 10 kilogauss. Dr. Simon mentioned that one could solve the more accurate equations involving the time dependence of the ion and neutral atom densities. The solutions of these non-linear coupled equations were obtained on an analogue computer and are shown in Fig. 4. The behaviour of these densities is shown as a function of the current for three values of the pressure. The arrow indicates the value of the critical current obtained from the simple equation on the previous slide. It is seen that this value is indicative of the critical point.

Dr. Simon asked the audience to suppose that burnout had been achieved. With charge exchange eliminated the hot ions would now degrade in energy by collisions with cold electrons. The energy lost, of course, served to heat these electrons. In steady state the ions would degrade in energy and the electrons heat until Coulomb scattering became more important than energy loss. At that point a plasma would form and one would have arrived at a potentially thermonuclear condition.

Dr. Simon used a simple model to indicate what the final plasma temperatures might be. This model is shown in Fig. 5. Here the hot ions entered at a single value E_0 and degraded in energy as shown until they got into a Maxwellian plasma at some temperature T_+ and at a density N_+. The final temperature T_+, was determined by a balance between the energy feeds shown by the dotted lines and energy lost by bremsstrahlung. The ion density was determined by the balance between input current and mirror loss. Finally, the electron density was fixed by the requirement of space charge neutrality. In this first, and very optimistic model, there was no provision made for an influx of cold electrons. The results indicated that in this case with 300 kilovolt injection energy the plasma would form at an average energy of about 280 kilovolts (kT is 2/3 of this value, however, energy is a more useful unit) and the electrons at 180 kilovolts. With an input current of 1 milliampere, for example, this would then produce a plasma density of about 10^{12} particles per cm^3.

Less optimistic models still gave encouraging results. For example, if ten times as many cold electrons as hot ions entered the system, and if these cold electrons had to be heated all the way up to the electron plasma temperature before they could escape, a final average ion energy of 90 kilovolts and an electron temperature of 23 kilovolts was still formed.

An important advantage to this scheme for producing thermonuclear plasma was the fact that there should be no ambiguity about the arrival at a thermonuclear state. For example, in the illustration one would obtain a total neutron yield from the volume of about 10^{12} to 10^{13} per second with a 1 milliampere input of ions. This same number of ions fired into a solid deuterium target would yield only about 10^8 per second. An increase of the yield from 10^8 to 10^{13} could only be accounted for

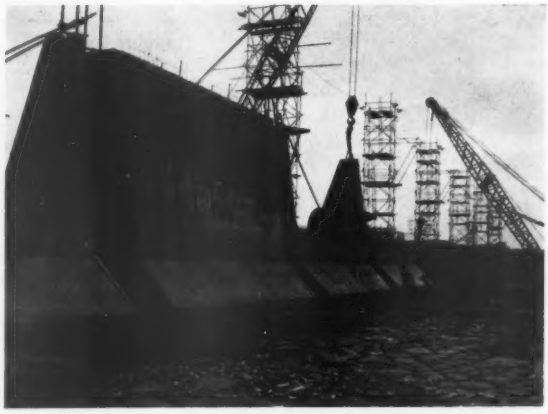
by the heating of the electrons and the formation of a plasma.

Dr. Simon explained that he was glossing over many possible difficulties. The arc itself, for example, might have unfavourable as well as favourable features. Fortunately, one of the most serious of these was known to be absent. Measurements by Barnett had established that less than one in 10^5 fast protons (300 kev) suffered a charge exchange in passing through the arc. The presence of the arc might contribute impurities as well as moderately cold electrons which tended to hold down the energy of the plasma. In this regard, it had to be kept in mind that the arc should be thought of as a plasma "igniter" rather than as a permanent feature of thermonuclear device. Once a partial plasma had formed, one would hope to shut off the arc and continue feeding the gas by using the molecular breakup occurring in the residual plasma. If, indeed, the plasma was well above the ignition point the high energy injection could be shut off entirely and cold feed used to sustain and even increase the plasma. It had to be kept in mind that the ideal operating energy of an actual operating reactor was well below the 300 kilovolt injection energy used in the previous illustrations, and was more like 60 kilovolts.

Other possible difficulties were things like partially ionized impurities, heat conduction to the walls, and instabilities. In the case of partially stripped impurities there again seemed to be advantages to working down in energy. Some preliminary calculations indicated that the heat transfer from the hot ions to the cold electrons was sufficient to raise the electron's energy above the level needed to ionize the impurities and hence remove them. For example, at 300 kilovolt injection energy using a typical impurity such as Carbon IV which had an excitation level at 8 volts above the ground state and ionization energy of 64 volts, it was found that even as large an impurity density as 5% of the plasma density failed to prevent the electrons from rising in energy to well above 64 volts.

Heat conduction to the walls might be serious. It was in the very nature of the Luce Ignition Scheme that the particles were deposited only one Larmor diameter of the atomic ion from the injection snout. The resultant heat transfer rate, if calculated assuming a linear temperature variation to the surface, could be appreciably larger than the bremsstrahlung loss. However, by simple calculations it was possible to show that heating from above still forces the final temperature to be of the order of 75 kilovolts or greater, even under pessimistic assumptions. From a long range view one would want to compress the plasma once after its formation by the Luce Ignition Scheme in order that it then be capable of retaining its own reaction products and be self-sustaining. This step would also take care of the heat transfer problem.

Finally, there was the question of instabilities. This was still very much an open question, particularly since the theoretical assumptions to date made use of hydrodynamic models which were far from valid at these larger Larmor radii and since they omitted the effect of electric fields. In any event, it would seem that a steady state device was an excellent one for studying the possible onset and control of these instabilities if they existed.



HINKLEY POINT.—Construction work is shown proceeding during low water on the 3000 ft long sea wall at the site of the world's largest nuclear power station, Hinkley Point, Somerset, being built for the Central Electricity Generating Board by the English Electric—Babcock & Wilcox—Taylor Woodrow atomic power group. When finished the wall will be over 18 ft high in places. Picture shows shuttering for the third concrete lift being put into position

Welding Problems in Nuclear Plant

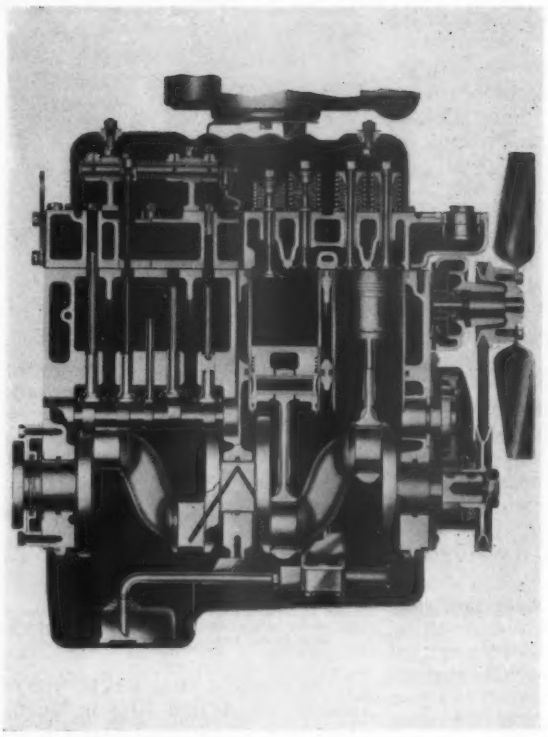
Some of the problems which are encountered in the welding of components for nuclear energy were outlined at a recent meeting of the Birmingham Branch of the Institute of Welding by Mr. I. H. Hogg, Welding Engineer to the Atomic Energy Authority at Risley, Lancashire. Among the subjects discussed was the fabrication of plant at Sellafield where stainless steel was used for all pipework. Preliminary tests using pressure welding and flash butt welding techniques were made but both methods were found to be unsatisfactory. Additional tests were made using the Argonarc process and when these proved satisfactory, this equipment was adopted. In all, some 10,000 pipe welds were made. The welds were subjected to radiographic testing and each one was found to be perfect.

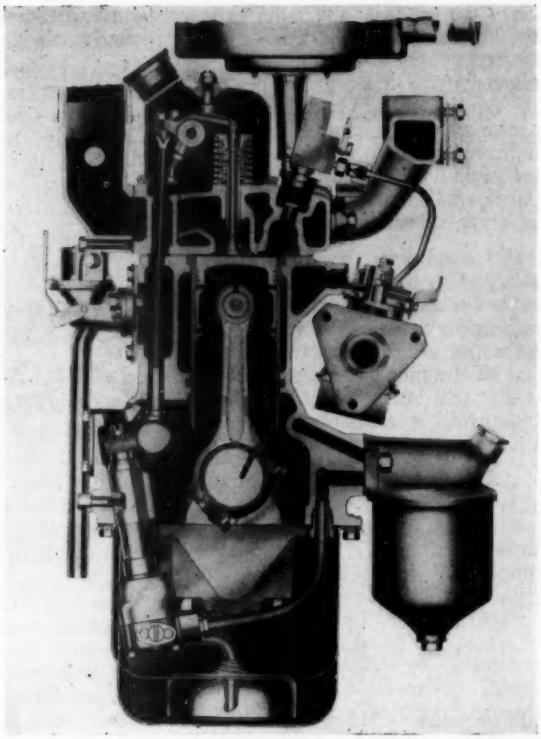
At Calder Hall Power Station, the dome was fabricated in two halves and lowered into position during the actual construction of the station. After final welding, the whole vessel was stress relieved to 600° C by radiant heating.

Discussing the pressurized water reactor for use in submarines, Mr. Hogg explained that walls of the vessel are required to be 8 in. thickness, with a cladding of $\frac{1}{4}$ in. stainless steel. For very high temperatures, a gas cooled reactor could be used.

Stressing the problems of maintenance in connexion with atomic reactors, Mr. Hogg described various methods whereby remote control welding or cutting could be applied when it was necessary to carry out repairs.

If one of the rarer metals, such as beryllium, is to be used, the toxic properties would have to be carefully considered during both welding and machining processes. Many of the problems associated with this type of reactor were as yet unresolved, but solutions would doubtless be found.





Longitudinal and transverse sections through the Perkins Four-99. A pintle-type combustion system is adopted for this engine which has a total capacity 1.6 litres and weighs (less flywheel) 320 lb

Challenger to the Petrol Engine— High Speed Diesel for the Small Car

Last year F. Perkins Limited, Peterborough, introduced two new diesel engines for agricultural machinery duties, the 3·14 litre P4/192 (TA) and the 1·6 litre Perkins Four 99 (TA) which were described in our columns.* The Four 99 has now been developed in a form suitable for private cars and light commercial vehicles. Its weight, less flywheel and starter motor is only 320 lb, the power rating being 43 bhp at 4000 rpm for cars and 42 bhp at 3600 rpm for vans and trucks. A slightly heavier model is also available for industrial duties and is rated at 32–35 bhp at 3000 rpm. Road tests have shown that the Four 99 can offer a performance comparable with the petrol engine. For example a Vauxhall Velox so fitted averaged 56·6 mpg at an average speed of 34·8 mph. Cruising and top speeds have also proved the equal of similar cars with petrol engines and have reached over 80 mph. Under adverse stopping and starting conditions of delivery van work a consumption of 38 mpg was achieved as compared with 15 mpg from a petrol engine for the same duty. Long life is an important claim made for these engines—the bore wear recorded after exhaustive road tests was equal to only ·001 in. after 20,000 miles service.

The new patented pintle-type combustion system which was a major feature of the Four 99 (TA) agricultural engine is again employed in this new engine. It is stated to promote complete combustion, utilize the maximum possible quantity of air and to result in a better performance throughout the wide range of engine speeds without creating smoke at high speeds. Other features in common with the earlier Four 99 series include the cylinder block cast integral with the crank case and fitted with cast iron wet liners, the low position mounting of the camshaft on the offside of the block in three bearings. The crankshaft is forged from chrome-molybdenum steel to B.S. En. 19T, the four balance weights being forged integrally with the shaft. Pin and main journals are induction hardened, and the rear of the shaft is machined to provide thrust location, oil thrower and oil return scroll. Oil seals are provided at the front and rear of the crankshaft. The front seal is a standard synthetic rubber lip type seal, fitted into the timing case cover, and the rear oil seal is of the rubber core woven asbestos rope type, retained in a split housing.* Crankshaft end float and thrust is taken up by steel backed copper lead thrust washers fitted in the cylinder block and bearing cap and the three main bearings are of the thin wall pre-finished steel backed, lead bronze lined type. The connecting rod big-end bearings are also of this type. The high silicon aluminium alloy piston is fitted with three compression and two scraper rings.

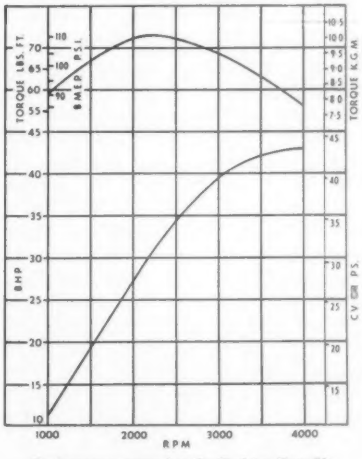
A Hobourn-Eaton type oil pump, secured to the cylinder block and located in the sump, is driven by spiral gears from the camshaft. An oil strainer in the sump is provided at the pump suction inlet, and the oil is delivered through a full flow filter on the near side of the engine to a main gallery drilled lengthwise through the crankcase. Drilled holes through the main bearing housings

* January, 1958, p.p. 40-41, February, 1958, p. 83.

carry the oil from the main gallery to the main bearings, from whence it passes via drilled holes in the crankshaft to the big end bearings. A supply of oil is taken to the centre camshaft bearing, where it is metered to feed the valve rocker levers and valve gear. The cylinder bores, small end bush and gudgeon pins are splash lubricated.

An open type breather pipe is attached to the pressed steel tappet cover for crankcase ventilation. Air movement assists in drawing fumes from the crankcase, and since the end of the pipe in the tappet cover is directed downwards, any oil mist is returned to the sump.

The C.A.V. type DPA fuel pump is designed for trouble-free running at speeds of well over 4000 rpm. The inertia masses are very small and variable timing is achieved very simply by hydraulic means. An automatic device can be also incorporated in the fuel pump to advance or retard the point of fuel injection according to changes of engine speed, for variable speed engines. Engine speed is controlled by a hydraulic governor on vehicle engines and a mechanical type governor in the case of industrial



Performance curve for the Perkins Four-99

power units. The speed control lever is located on the fuel pump with an engine stop lever.

A fuel lift pump of the diaphragm type and equipped for hand priming is operated by an eccentric from the camshaft, via a small push rod. The atomisers are located on the near side of the cylinder head in an accessible position. Provision is made for mounting a paper element type fuel filter on either side of the cylinder block.

Special conversion engine sets are now available to replace existing petrol units in the Ford Consul, Vauxhall Velox and Wyvern, the 55/56 Bedford 12 cwt van, the Austin Omnivan and the Morris J2 van. Conversion kits are also pending for other vehicles such as the Ford 12–15 cwt van.

Twenty-five ton Diesel-electric Crane Slews on Ball Bearings

An interesting development in crane design is featured on the Coles L3010, a heavy duty, truck-mounted, diesel-electric crane with a lifting capacity of 25 ton at 10 ft radius when fitted with a 30 ft centres strut jib.

This is the ball bearing slew ring, the crane superstructure revolving on a large diameter double ring of steel ball bearings which obviates the need for a centre post and give a more even distribution of loading on the chassis frame.

Conforming to the usual Coles design, the crane employs diesel-electric transmission, a 61 hp diesel engine directly coupled to a variable voltage generator which in turn supplies current to the three separate electric motors of the hoist, derrick and slew motions. These motions may be operated individually or simultaneously.

The totally enclosed operator's cab is conveniently positioned on the front of the revolving superstructure and allows the operator an unrestricted view of the hook and working area. All the controls are suitably positioned to reduce operator fatigue and the cab itself may be constructed to suit extreme climates. The chassis robustly constructed for heavy duty with a 6 × 4 wheel base is powered by an A.E.C. 6-cylinder diesel engine and transmission is through a single plate dry clutch and gearbox providing five forward and one reverse speed which may be further reduced by an auxiliary box to give an additional range of low gear ratios for poor working conditions. A 6-wheel drive may be fitted for improved cross-country performance and tailweight removal gear enables the crane to reduce overall weight for travelling duties.

Coles L 3010, a truck-mounted diesel-electric heavy duty crane with a lifting capacity of 25 long ton at 10 ft radius with a 30 ft centres strut jib

The standard jib is a strut type of lattice construction 30 ft in length. This may be extended to 120 ft by inserting extension pieces. A gantry mast is available to enable the crane to raise jibs longer than 80 ft from the horizontal position and for use with self-erecting jibs.

Another advance in the Coles design is the pilot switch system of control. With this method the operator merely selects the appropriate switch, located on a console in the cab superstructure and then controls the speed of motion by depressing the engine accelerator. All the simple heavy duty reversing contactors are housed in a robust steel box situated in a readily accessible position at the base of the superstructure. The safety devices are integral with the construction of the machine and not superimposed. A safe load indicator gives audible and visual warning should attempts be made to overload the crane and electro-mechanical brakes are immediately and automatically applied to the hoist, derrick and slew motions should the supply of current be interrupted intentionally or accidentally. Totally enclosed self-resetting limit switches prevent hoisting and derricking beyond the prescribed limits.

Coles cranes are designed, manufactured and marketed by Steels Engineering Products Limited, Sunderland.

books

The Practical Engineer Pocket Book. Edited by N. P. W. Moore. London, 1958; Sir Isaac Pitman & Sons Limited. 12/6 net (by post 13/2). 744 pp. 5½ × 3½ in.

The 66th edition of this well-known pocket book has a largely rewritten section on metallurgy and also new matter on creep of materials and new steam tables. For the rest the compilation is a useful blend of principles and practice in many of the established branches of mechanical engineering, covering engines of all kinds, compressors, pumps, and the regular workshop methods. Also included are technical dictionaries in German, French and Spanish.

European Economy.—The United Nations "Economic Survey of Europe in 1957" (H.M. Stationery Office, 28/- net) shows that the situation in Eastern Europe turned out to be better than had been expected following events in Hungary and Poland. Industrial production there was higher, flow at all stages was more uniform, with the accent more on consumer goods. In Western Europe a continued lessening of the growth of expansion was noticed; and as to 1958 the authors of the survey find little prospect of the rate of expansion being maintained as long as present trends and policies are maintained.

Port of Aden.—In the Port of Aden Annual (Letchworth Publishing Agency Limited, Norton Way, North Letchworth, Herts., 2/-) Mr. A. Gray, O.B.E., M.Inst.C.E., describes the engineering equipment of the port, comprising floating craft for handling or attending upon shipping, and special purpose craft connected with the handling of lifts, engineering works, survey and mooring requirements and general maintenance, and land equipment comprising modern diesel-electric cranes and fork lift trucks. A fully mechanized plant was envisaged some years ago but was dropped in favour of employing the plentiful coolie labour. The picture has changed since then; unions have been formed and the cargo coolies have ruled that they will not lift packages over a certain weight, and their wages are higher. Modern mechanization would therefore seem to be inevitable.

"Safety".—A new magazine of this title is being published by the Accident Prevention Committee of the British Iron and Steel Federation, Steel House, Tothill Street, London SW1, three times a year. It features articles, reports and reviews, correspondence and information on a wide variety of subjects connected with accident prevention and industrial health. Examples include references to the work of other countries and other industries, as well as to safety hazards in the home.

U.K. Oil Consumption.—Last year, consumption of oil products in the U.K., excluding foreign bunkers, totalled 24,736,541 tons—1·9% below that for 1956—according to details published by Petroleum Bureau. This was the first occasion since 1946 when demand was below that for the previous year, and the fall was more than accounted for by the reduction in the use of oil during the first half of the year, when rationing and other restrictions on consumption resulting from the Suez crisis were in force. Over the second six months, demand was generally at a higher level than in the latter half of 1956. Fuel oil deliveries—excluding those for refinery consumption—were 6,930,713 tons or 7·1% up on the year before. Gas/diesel deliveries, at 2,341,362 tons, were lower by 1·9% than in 1956, although in the second half of the year sales were higher than in July–December 1956. Over the full year deliveries of motor spirit were 5,745,029 tons, representing a decline of 9·2% over 1956. Consumption of derv fuel was 1,795,154 tons (only 2,000 tons below that for 1956); deliveries of burning oil (795,432 tons) were 4·3% down on the year; those of vaporizing oil (519,469 tons), aviation fuels (1,581,779 tons), lubricating oils (826,496 tons) and bitumen (848,389 tons) were also lower than a year before. In contrast there was a 19% increase in deliveries of "other products"—totalling 794,598 tons—which was largely associated with the rapidly expanding use of oil as feedstock in the manufacture of chemicals.

New Standards

Wire Rope Fittings

Bordeaux connexions (B.S. 461: 1958). Price 5/-.

Bulldog grips (B.S. 462:1958). Price 4/6.

Drop-forged sockets for wire ropes for engineering purposes (B.S. 463: 1958). Price 5/-.

Thimbles for wire ropes (B.S. 464:1958). Price 5/-.

Rigging screws and stretching screws for general engineering purposes (B.S. 716:1958). Price 7/6.

Wire rope slings and sling legs (B.S. 1290:1958). Price 10/-.

B.S. 461 specifies the dimensions, materials and inspection, testing and certification requirements for the fittings ("Bordeaux connexions") used for attaching wire rope to short link chains. The specified sizes of wire rope range from ½–1⅜ in. dia.

B.S. 462 specifies materials and dimensions for the fittings ("Bull dog grips") used to secure the end of wire rope as an alternative to splicing or socketing. The range of nominal sizes is $\frac{5}{16}$–2¼ in.

B.S. 463 specifies materials and dimensions for drop-forged sockets, of the open or closed types, for wire ropes of $\frac{5}{16}$–1⅝ in. dia. One of the two appendices gives a recommended method of hot white metal socketing. The dimensional tables for open type sockets and closed type sockets are shown in conjunction with annotated diagrams.

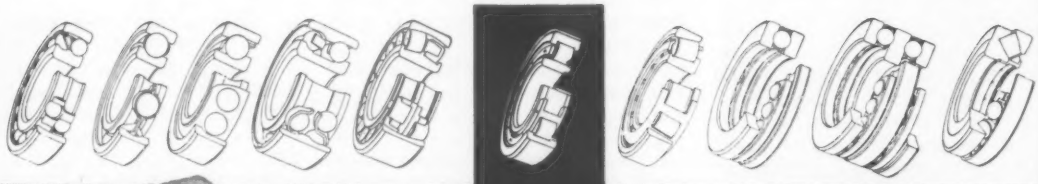
B.S. 464 specifies materials and dimensions for thimbles for wire ropes of nominal sizes from $\frac{5}{16}$ to 2¾ in. The types of thimble specified are: Ordinary: $\frac{5}{16}$–2½ in. Reeving: ⅝–1½ in. Solid: $\frac{5}{16}$–2½ in. An appendix to the standard gives a recommended method of making a wire rope thimble splice

B.S. 716 specifies materials, components, dimensions, finishing requirements and tests for rigging screws and stretching screws of nominal size ½–2¼ in. and ¼ to 2 in. respectively.

Finally, B.S. 1290 specifies the dimensions, construction, loading and marking and test requirements for one-, two-, three- and four-leg slings with legs of the following types: single part sliced, double part sliced endless and double part grommet. The slings are for use with wire ropes of $\frac{5}{16}$–1¼ in. nominal dia.

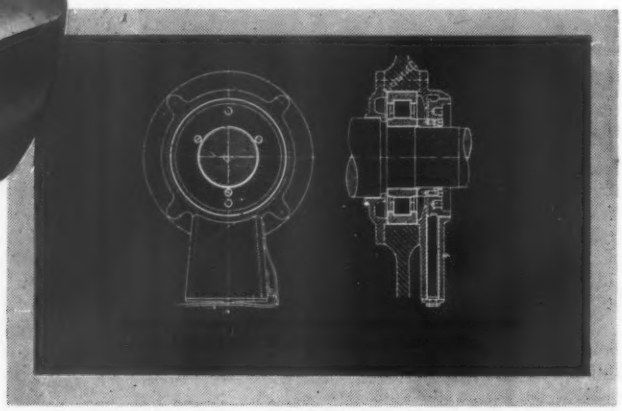
British Standards Institution, 2 Park Street London, W1.

Only SKF can offer such a wide selection of British made bearings



Illustrated on the left is the SKF cylindrical roller bearing, one of the ten variants of the four basic types of rolling bearing manufactured in Great Britain by The Skefko Ball Bearing Co. Ltd. The cylindrical roller bearing has a low coefficient of friction and is therefore suitable for shafts operating at high speeds. Because of its high radial carrying capacity it is extensively used in electric motors, gearboxes and similar applications.

Behind every SKF bearing lies unrivalled experience in the design and application of rolling bearings all over the world. This experience is at your disposal from any one of Skefko's twenty Branch Offices, situated at strategic points all over the British Isles.



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BUSINESS & PROFESSIONAL

Personal

Mr. Arthur Makin, director and secretary of Marshall Sons & Co. Limited, Gainsborough, and director of a number of its subsidiary and associated companies, has now resigned these appointments. His services are being retained in an advisory capacity. **Mr. F. J. Wallace, F.C.I.S.,** who has assisted Mr. Makin for a number of years, has succeeded him as secretary.

Mr. W. Nunn was recently appointed export sales manager of the engineering tool division of Brayshaw Furnaces & Tools, Limited, Belle Vue Works, Manchester, 12. Mr. Nunn was formerly head of the export department, Joseph Thompson (Sheffield) Limited.

Mr. S. F. Smith has recently taken up an appointment as sales manager of the industrial instruments division of Firth Cleveland Instruments Limited, Treforest, Glamorgan. Mr. Smith, who was previously with Philips Electrical Limited will operate from the sales department, Byron House, 7-9, St. James's Street, London, S.W.1.

Mr. P. A. Hearne has been appointed sales manager of British Oxygen Aro Equipment Limited in succession to **Mr. David Ince, D.F.C.,** who is taking up an appointment as divisional manager of the guided weapons division of Elliot Brothers (London) Limited. Mr. Hearne was formerly a member of the project branch of B.O.A.C. and more recently was a helicopter project engineer with B.E.A., being responsible for development work on civil helicopters.

VICKERS LIMITED announces that **Sir Thomas R. Merton, K.B.E., F.R.S.,** having reached normal retirement age, has vacated his seat on the board of directors. **Sir Sam H. Brown** has been appointed an additional director. In consequence of his appointment as managing director of Vickers-Armstrongs (Engineers) Limited, **Mr. W. D. Opher, M.I.Mech.E.** has relinquished the general managership of the Barrow Works and is succeeded there by **Mr. A. Storey,** who has also been appointed an additional member of the board of directors of Vickers-Armstrongs (Engineers) Limited. Further changes in the Group are the resignation of **Mr. E. J. Waddington, A.C.A.,** from the boards of Vickers-Armstrongs (Aircraft) Limited, Vickers-Armstrongs (Engineers) Limited, Vickers-Armstrongs (Shipbuilders) Limited and Vickers-Armstrongs (Tractors) Limited; and the appointment of **Mr. J. H. Robbie, C.A.,** to the boards of Vickers-Armstrongs (Aircraft) Limited, Vickers-Armstrongs (Shipbuilders) Limited and Vickers-Armstrongs (Tractors) Limited. Mr. Robbie has also been appointed controller of finance of Vickers Limited, responsible to the director of finance of Vickers Limited.

Mr. J. T. Rees, of British Thomson-Houston Switchgear Contracts, Willesden, retired on April 23, after forty-seven years' service with the company. Mr. Rees received his technical education at Bangor University and served his apprenticeship with the old National Electric Construction Company in Caernarvon. He joined BTH in March, 1911. Keenly interested in railways, Mr. Rees has been a member of the Model Railway Club for over thirty years, during which time he has been closely associated with the Club's increasingly popular annual exhibitions at Central Hall, Westminster.

Mr. J. B. Clarkson has been appointed a director of Clarkson (Engineers) Limited Nuneaton, and is expecting to leave shortly for Germany, where he will be joining the subsidiary company, Clarkson G.m.b.H. at Mettmann/Rhld, near Dusseldorf.

Mr. S. S. Carlisle, M.Sc., A.M.I.E.E., head of the South Wales laboratories of the British Iron & Steel Research Association since February 1954, has been appointed head of the physics department at BISRA's Battersea laboratories. In addition he will continue to have an executive responsibility for the South Wales laboratory as deputy head of the mechanical working division (Swansea). He is succeeded at Sketty Hall by **Mr. W. N. Jenkins, B.Sc., A.M.I.E.E.,** of the electrical engineering section of BISRA's plant engineering division at Battersea.

Vice-Admiral Sir Frank Mason, K.C.B. (Engineer-in-Chief of the Fleet 1953-57) has joined the board of directors of H. W. Kearns & Co. Limited, Broadheath, makers of Kearns horizontal boring machines.

Mr. F. O. Ackroyd, A.M.I.Mech.E., A.M.I. Prod.E., has been appointed to the board of Crofts (Engineers) Limited.

TUBE INVESTMENTS LIMITED announce that **Mr. A. J. S. Aston** and **Mr. R. D. Young** have been appointed to the board.

Mr. A. E. Curtis, works manager, and **Mr. N. C. Hodson,** London sales manager, have been appointed directors of Aldridge Plastics Limited, a subsidiary of Siemens Edison Swan Limited.

Mr. J. G. Smith, M.I.C.E., M.I.Mun.E., has been appointed a deputy chief engineer (civil engineering) on the highways engineering staff of the Ministry of Transport and Civil Aviation.

EDGAR ALLEN & COMPANY LIMITED announce the appointment of **Mr. Fred Haigh** as from April 1, 1958, as personal assistant to Mr. B. B. Green, a director and general sales manager of the company. **Mr. Irving Somerfield** has been appointed home sales manager (Steel, Engineers' Tool, Magnet and Saw Departments) and **Mr. E. Ashurst** succeeds Mr. Fred Haigh as commercial manager of the foundry division. **Mr. J. P. Lewis,** formerly sales engineer of the Edgar Allen engineering department, has been appointed general manager of The British 'Rema' Manufacturing company Limited, with **Mr. T. R. Wadsworth** as assistant general manager.

THE following staff changes and appointments with the National Industrial Fuel Efficiency Service are announced: **Mr. C. A. J. Plummer, M.Sc., M.Inst.F.,** area engineer, Midland area; **Mr. K. Higginson, B.Sc., M.Inst.F.,** area engineer, North Eastern area; **Mr. R. Clare, B.Sc., M.Inst.F.,** area engineer, North Western area; **Mr. L. F. Linnett, B.Sc., M.Inst.F.,** area engineer, Northern Ireland; **Mr. W. Short, B.Sc., M.Inst.F.,** area engineer, Wales. **Mr. George Gill,** formerly area engineer in the North Western area, and **Mr. A. H. Pinder,** formerly area engineer in the Midland area, are appointed group managers in the northern and southern sections of the United Kingdom respectively. They will be responsible for co-ordinating the work of the four areas in each of their groups, and facilitating the liaison between N.I.F.E.S. area engineers.

Mr. Sebastian Z. de Ferranti has been appointed managing director of the heavy electrical engineering firm of Ferranti Limited. **Sir Vincent de Ferranti** remains chairman of the company.

Mr. Thomas F. W. Jackson has been appointed chairman and managing director of Union Carbide Limited in succession to the late Mr. W. B. H. Gallwey.

Mr. H. M. Henderson, a director of United Steel Structural Company Limited, Scunthorpe, and formerly general sales manager of the parent company, has been appointed managing director of Unisteel Structural (Pty.) Limited of Capetown. He succeeds **Mr. J. W. Mitchell,** resigned. Mr. Henderson has been additionally appointed a director of Unisteel Africa (Pty.) Limited, of Johannesburg. **Mr. R. C. Gervers,** managing director of Unisteel Africa, is also a director of Unisteel Structural.

E.M.I. ELECTRONIC LIMITED announce the appointment of **Mr. R. W. Addie** to the board as marketing director. A qualified

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There can be no tool bit chatter or loss of rigidity with Eclipse tool holders. The patent clamp grips the tool along its full length, exerting pressure both downwards and sideways, to hold the tool absolutely rigidly.

Made in right-hand, left-hand and straight patterns in two sizes - $\frac{3}{16}$" to $\frac{1}{4}$" and $\frac{5}{16}$" to $\frac{3}{8}$". Other models for American type tool posts in four sizes - $\frac{1}{4}$" to $\frac{3}{8}$" - $\frac{7}{16}$" to $\frac{1}{2}$" - $\frac{5}{16}$" to $\frac{3}{8}$" and $\frac{3}{8}$" to $\frac{1}{2}$". Also cutting off tool holders in three sizes - $\frac{1}{2}$" to $\frac{5}{8}$" - $\frac{11}{16}$" to $\frac{7}{8}$" - 1" to 1$\frac{1}{8}$".

Made by James Neill & Co. (Sheffield) Ltd., and obtainable from all tool distributors

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engineer before going over to the commercial side, Mr. Addie joined the company six months ago as export manager.

Mr. David F. Craig has been appointed to to the board of Liquid Systems Limited Norwich Union House, Wellesley Road, Croydon.

THOMPSON BROTHERS (BILSTON) LIMITED, of Bradley Engineering Works, Bilston Staffs., announce that **Mr. E. E. Pheasey, M.B.E., M.I.B.E.,** has been appointed works director. He was previously with Messrs. Foster, Yates and Thom, general engineers of Blackburn, Lancs.

B.E.N. PATENTS LIMITED announce the appointment of **Mr. J. E. Spence, M.I.Mech.E.,** general sales manager, as a director of the company. The company also announces the following rearrangement of territorial representation: **Mr. R. J. Pettitt** of 2, Sancroft Road, Harrow Weald, Harrow, Middlesex, will cover the County of Essex and London Postal districts N.E. and E.C. **Mr. A. H. Stenning** of 5, Woodville Gardens, Ealing, W.5., will cover the County of Middlesex and London Postal districts W., N.W. and S.W. areas north of the Thames. **Mr. E. B. Holiday, A.M.I.C.E., A.R.I.C.S.,** former deputy chief road engineer for Scotland, has been appointed an assistant chief engineer (Civil) on the Highways Engineering Staff. **Mr. D. J. Swift, B.Eng., M.I.C.E.,** has been appointed to succeed Mr Holiday as deputy chief road engineer, Scotland, of the Ministry of Transport and Civil Aviation.

Obituary

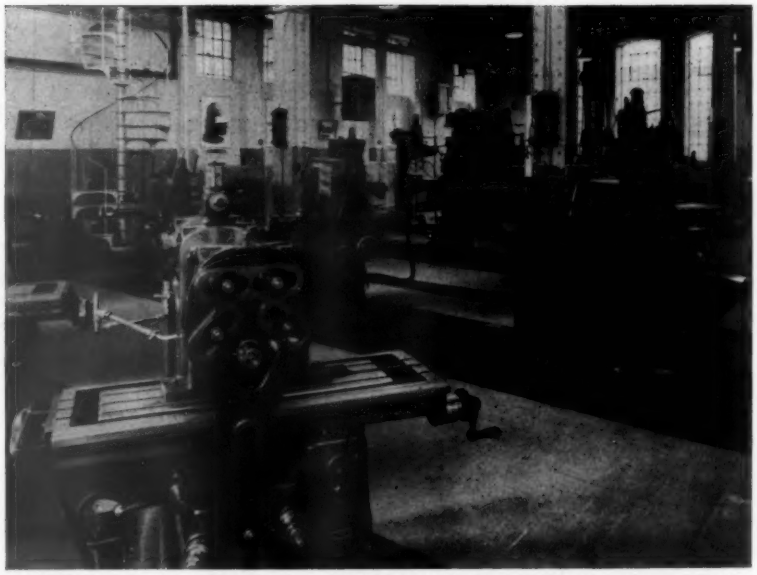
WE regret to record the death of **Mr. P. H. Muirhead, C.B.E.,** a director of Vickers Limited and of other companies, and until January last managing director of Vickers-Armstrongs (Engineers) Limited. Mr. Muirhead, who was 53 years of age, joined the Elswick Works in 1927.

WE regret to record the death of **Mr. A. H. Waine, F.I.M., A.I.Mech.E.,** a director of Hadfields Limited and managing director of the subsidiary company Hadfields Forgings Limited. Mr. Waine, who was on a business tour of Germany, Holland and Belgium, was taken ill and died suddenly in Brussels. He was 57 and had been with Hadfields Limited for over 40 years.

WE regret to record the death at the age of 50, of **Mr. Edmund Arthur Lawson-Brown,** service engineer in the traction department of the British Thomson-Houston Company Limited. Mr. Lawson-Brown joined BTH in 1951 on his return from India where he had served for two years with A.E.I. (India) Limited.

Addresses

WILD-BARFIELD ELECTRIC FURNACES Limited announce that the address of the Wild-Barfield branch office in Canada has been changed to: 77 Grenville Street, Toronto, Ontario. The telephone numbers remains as hitherto, Walnut 4-2809.



MACHINE TOOL SHOWROOM.—James Archdale & Co. Limited have opened this new showroom at their Ledsam Street Works, Birmingham 16. Intended principally for the display and demonstration of a representative selection from their very wide range of radial, vertical and multiple-spindle drilling machines, hydraulic feed drilling units and the twist drill grinding machine, there are also provided full facilities for observing the equipment in operation and fully trained staff are in attendance to assist with problems

THE BRITISH 'REMA' MANUFACTURING Company Limited announce that their head office address is now One Industry Road, Darnall, Sheffield, 9.

THE UNITED STEEL COMPANIES LIMITED announce that Patchett Steel Constructions (Pty.) Limited, of Cape Town, has changed its name to Unisteel Structural (Pty.) Limited, and is now a wholly-owned subsidiary.

INSTRUMENTS (HUDDERSFIELD) LIMITED has now changed its title to Sanderson Instruments (Huddersfield) Limited, and will be trading under the style of Sanderson Instruments in the future.

PADLEY & VENABLES LIMITED of Suprex Works, Livery Street, Birmingham, are removing to new and larger premises at Middlemore Lane West, Aldridge, Nr. Walsall, on the Redhouse industrial estate. The factory has specialised equipment for the processing of stainless steel in the form of sheets, bars, tubes, sections, etc.

THE North West Regional Office and depot of Dexion Limited, slotted angle manufacturers, has moved from the Kirkby Industrial Estate, near Liverpool, and is now at Sandy Lane, Lowton, near Warrington, Lancs. New telephone number, Leigh 1568.

AERO RESEARCH LIMITED, Duxford, Cambridge, have announced that from June 30, 1958 the name of the company has been changed to CIBA (A.R.L.) Limited. Aero Research was formed in 1934 to pioneer research into aircraft structures, including the development of new adhesives. The trade names for Aerolite, Araldite, Redux, and other proprietary products are unaffected.

BRITISH MONORAIL LIMITED has moved to a new, modern factory in Wakefield Road, Brighouse, Yorkshire. Since its formation in 1952, the company has been at Wren Works, Chadderton, Lancashire, formerly a cotton mill. The new telephone number is Brighouse 2244 (five lines).

CHAMBERLAIN PLANT LIMITED, one of the Chamberlain Group of Companies, have moved to their new works and offices at Crown Works, Southbury Road, Enfield, Middlesex.

PERKINS C.M.E. LIMITED, Derby, will shortly open showrooms in London for the display of oil fired domestic and industrial boilers. The London office will cover the area south of a line from Gloucester to Colchester and will be under the managership of Mr. J. Russell Hickmott, with temporary offices at 83 Cromwell Road, London SW19 (Liberty 7222).

New Transistor Company

AUTOMATIC TELEPHONE & ELECTRIC Company Limited, The English Electric Company Limited and Ericsson Telephones Limited have formed a jointly owned company for the development and manufacture of transistors and other semi-conductor devices. The company, to be known as Associated Transistors Limited, has an

Reduce your costs with:

GOODYEAR

LONG LENGTH

AIR HOSE

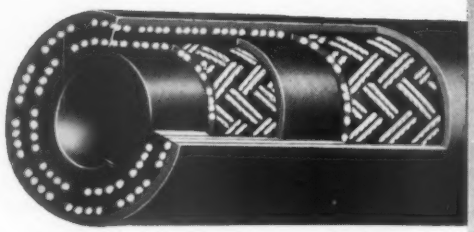
Whatever your air hose job, you can reduce your costs by using Goodyear Long Length Hose. It's your most economical buy—

BECAUSE
it can be cut to any length up to 500 ft., so eliminating hose wastage.

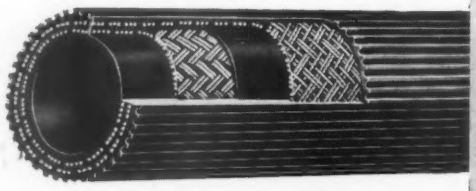
BECAUSE
it needs fewer couplings. Cuts not only the initial expense of couplings but also cost of maintaining them.

BECAUSE
it lasts longer. Goodyear Long Length Hose has a non-porous tube and abrasion-resistant cover built of high grade compounds for maximum wear.

Light in weight and of balanced construction, Goodyear Long Length Air Hose is easy to handle and resists kinking. There are two types of this hose—Style A and Style B, both available with smooth or corrugated covers.



STYLE A *for service where oil mist may be present in the line, and where operating pressures up to 325 lbs. per sq. in. are used.*



STYLE B *for general, light and medium pneumatic tool service and working pressures up to 210 lbs. per sq. in.*

Full details of both types can be obtained from Industrial Rubber Products Dept., Goodyear, Wolverhampton. We will also be pleased to advise on any air hose problem you have.

Specify

GOODYEAR

INDUSTRIAL RUBBER PRODUCTS

HOSE · V-BELTS
CONVEYOR BELTING
TRANSMISSION BELTING
FENDERS

authorised capital of £750,000 and is constructing a factory at Ruislip, Middlesex of some 55,000 sq ft.

The Design Centre and Trade Buyers

DESIGN Index at the Design Centre, 28 Haymarket, London SW1 is now reserved each morning from Monday to Friday for buyers only: the public will be excluded during the mornings and the Centre hopes that buyers will choose to make their visits at that time of the day. Design Index is a photographic and sample index of British goods of good design in current production. Some 9000 products are included. A free telephone service and other facilities are provided.

Rocol in South Africa

THE South African Government Post Office have subjected a number of appropriate Rocol Molybdenized lubricants to intensive practical tests which have proved completely satisfactory. Rocol lubricants have now been officially approved and adopted and are now in regular use. This official adoption is of interest to both the manufacturers and the users of telecommunication equipment. Anti-scuffing oil, Molytone 380 grease and Molytone L.M., are developed and manufactured in Britain by Rocol Limited, Swillington, near Leeds.

Careers in Steel

THE UNITED STEEL COMPANIES LIMITED have issued three booklets dealing respectively with training for student apprentices, careers for graduates, and careers in research and development. The first-named describes training facilities and careers available in The United Steel Companies Limited for boys leaving public and grammar schools with advanced G.C.E. The second deals with the recruitment of graduates for permanent appointment to the managerial, research and commercial staffs, and the third describes the opportunities for graduate scientists and engineers in research and development. They are available from the Company Recruitment Officer, The United Steel Companies Limited, 17 Westbourne Road, Sheffield 10.

The Two Millionth Motor

ORDERED through Brook Motors American subsidiary, the Brook Motor Corporation of Chicago, this 200 hp motor just completed was part of a consignment of six drip proof motors for Mexico—the two millionth Brook industrial type electric motor. The first million industrial motors were completed in 46 years, the actual motor made in 1950 was retained by the company. The second million has been completed in only seven and a half years.

Largest Galvanizing Line

THE main contractors for the new galvanizing plant at Ebbw Vale works of Richard Thomas and Baldwins Limited, described in the Log sheet pages of our June issue were the Head Wrightson Machine Company Limited of Middlesbrough, who subcontracted the whole of the furnace equipment, viz: flame cleaning, annealing, and galvanizing furnaces, together with the furnace atmosphere generating plant, to Birlec Limited.

Australian-made Macson-Town Drilling Machine

THE manufacture of radial drilling machines in Australia, under licence from Fredk. Town & Sons Limited, Halifax, Yorkshire has now begun at the factory of the company's Australian representatives, McPherson's Limited. The first of the Macson-Town machines to come off the production line is the Model A.E.5 42 in. sensitive radial drilling machine.

L.D.C. Price Reductions

LANCASHIRE DYNAMO & CRYPTO LIMITED recently announced price reductions in their range of British Standard dimensioned totally enclosed fan-cooled S.C.R. motors up to 25 h.p. (B.S.2083). Price reductions were also made recently in their range of B.S. ventilated motors to B.S.2960.

The "Staffa" Part Exchange Scheme

CHAMBERLAIN INDUSTRIES LIMITED of Staffa Works, Staffa Road, Leyton, London E10, have now introduced a part exchange service which permits users of "Staffa" portable two inch capacity two-stage hand operated oil hydraulic tube bending machines to exchange their existing pump and ram units for reconditioned units.

Anglo-U.S. Co-operation

THE ENGLISH ELECTRIC COMPANY LIMITED have signed agreements for the manufacture and use in Britain of a range of the most modern U.S. gyroscopes with Honeywell-Brown Limited of Perivale, Middlesex, and Minneapolis Honeywell Regulator Company of Minneapolis, U.S.A. Provision is made for an exchange of information on future gyroscope developments. The gyroscopes will be made by English Electric's Guided Weapons Division in a specially designed new factory at Stevenage, Hertfordshire. Marketing, both at home and overseas, will be done jointly by English Electric and Honeywell-Brown Limited which is the British associate of Minneapolis-Honeywell.

Contracts and Work in Progress

TAYLOR WOODROW (BUILDING EXPORTS) Limited, London.—A further contract in the region of £250,000 placed by the Plan Organization of Iran for a textile mill at Shahi Iran.

ORDERS for electrical equipment amounting to £1,600,000 have beeen placed with British firms in connection with a project by Compania Shell de Venezuela for the disposal of the crude oil produced from the oilfields around and in Lake Maracaibo in Western Venezuela. The firms are: South Wales Switchgear Company Limited, Blackwood, Mon.—Order value £½ million for switchgear and control gear for valves etc. A. Reyrolle & Company Limited, Hebburn-on-Tyne—High tension switchgear and control boards for the new power plant main extension. Value £200,000. British Insulated Callender's Construction Company—Transmission lines etc. value over £200,000. English Electric Co. Limited—Sub-stations costing £150,000. British Thomson-Houston Co. Limited—Transformers costing £300,000. C. A. Parsons & Co. Limited—Transformers. Crompton Parkinson Limited—Transformers.

E.M.I. ELECTRONICS LIMITED, Hayes—Electronic control system for powered trolleys for British Railways (Western Region).

THE ENGLISH ELECTRIC COMPANY LIMITED.—Contract worth some £980,000 from the Central Electricity Generating Board for generator, feeder station transformer, etc. for Hinkley Point Atomic Power Station in Somerset.

METALECTRIC FURNACES LIMITED, Smethwick.—Order from A/S National Industri, Oslo, for a continuous electric furnace for stress relieving silicon steel transformer laminations.

BIRLEC LIMITED, Birmingham.—Two electric arc melting furnaces for British Railways Midland Region, Crewe foundry.

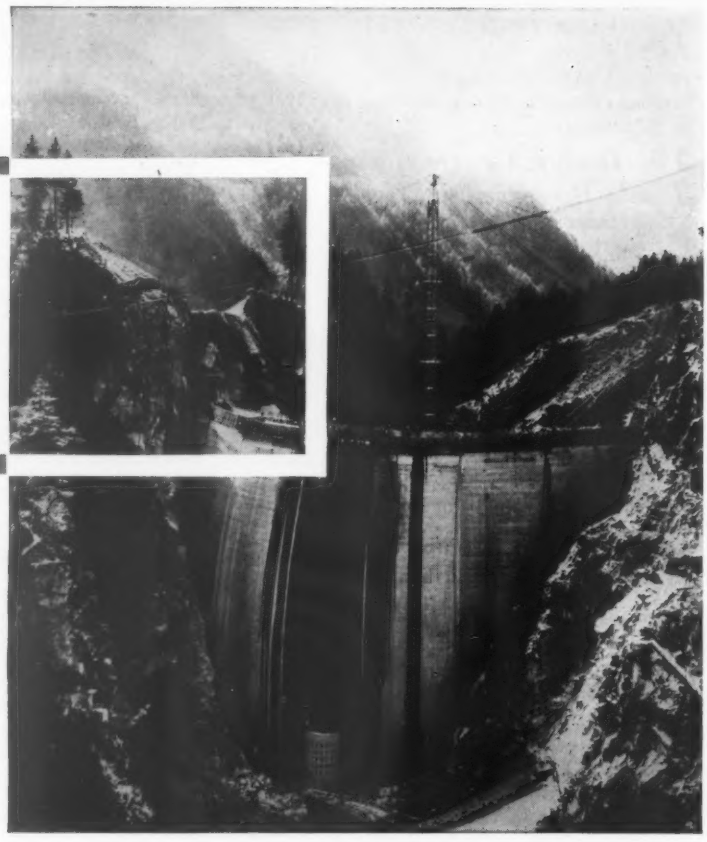
P. & W. ANDERSON (GLASGOW) LIMITED—New diesel repair shop for B.R. Grangemouth Motive Power Depot.

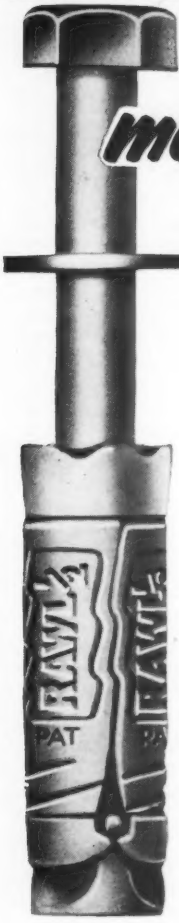
THE CLAYTON CRANE & HOIST CO. LIMITED, Liverpool—Nine 1-ton electrically operated hoist blocks for B.R., Motherwell, long rail welding installation.

THE WESTINGHOUSE BRAKE & SIGNAL CO. Limited, London.—Automatic train control Edinburgh Waverley to Glasgow Queen Street.

FLEMING BROS. (STRUCTURAL ENGINEERS) Limited, Glasgow.—Design and erection of B.R. rolling stock maintainance depot, Hyndland.

Rawlbolts hold a mountain face!





This photograph is a challenge to your imagination. It was taken in the Dolomites in Italy. The fractured mountain face on the left threatened to collapse. It is now held in safety — with *Rawlbolts*. How was it done?

12 tons per Rawlbolt

The whole area shown in the square was supported by K20 Rawlbolts, with high grade tensile steel rods, embedded into the rock to a depth of 66 feet. The Rawlbolts were so spaced as to take a constant load of 12 tons each. It is this standard of performance that accounts for the vast numbers of Rawlbolts used throughout industry every year.

It's the world's speediest bolt-fixing

A Rawlbolt is fixed in minutes — no chiselling, no subsequent grouting in, no waiting for cement to harden. You drill the material, insert the Rawlbolt, tighten up. It is ready to take its full load, *at once*.

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Trade Literature

Grey Iron Castings

Improved grey cast iron with easier machinability without loss of strength is the keynote to Automatt iron—a close grey iron resistant to "chill" which has been developed by The Refined Iron Company (Darwen) Limited, Spring Vale Works, Grimshaw Street, Darwen, Lancs. Full details of its capabilities are contained in an illustrated brochure.

Hydraulic Power Pack

With the exception of the hydraulic actuators—cylinders or motor—all equipment including pump filter, air cleaner control valves and recording instruments is built into the tank unit of the Keelavite power pack. The units and a range of hydraulic motors in a hp range from fractional to 300 are illustrated in leaflets from Keelavite Rotary Pumps & Motors Limited, Allesley, Coventry.

Power Capacitors, 200-600 V

A unit principle of construction is employed by British Insulated Callender's Cables Limited, 21 Bloomsbury Street, London WC1, for their MW power capacitors. Each primary unit is rated at approximately 1 kVAr and by means of single, two and three-tier assemblies it is possible to build up compact closely graded capacitor ratings as desired. Full details of construction, and ratings are contained in a new publication No. 401.

Sintered Bronze Friction Linings

Information about Sinterlink, a new sintered bronze clutch facing material developed by The Morgan Crucible Company, Battersea Church Road, London SW11, is contained in their publication No. SD60. The material which is offered in six grades is able to withstand a maximum surface temperature of 800° C. The transfer of heat through the lining is good and small particles of "free" lead and graphite in the metal provide a measure of dry lubrication. Complete clutch plates with Sinterlink facings bonded in position are available in a range of sizes.

Automatic Hydraulic Marking Machine

An automatic marking machine suitable for marking bearing rings up to 2½ in. dia, hexagon nuts and pipe fittings is described in leaflet No. 63 by the makers Edward Pryor and Son Limited, Broom Street, Sheffield 10. The machine, Model E.P.40 is designed for marking rates up to 2000 pieces per hr. Two 4½ dia hydraulic cylinders provide loads up to 20 ton. The gear-type pump is direct driven by a 3 hp motor.

Pulley Mounted Centrifugal Fans

Designed for heavy duties and rigorous conditions of operation encountered in extracting fumes and entrained dusts, the P.R. Uniform pulley mounted centrifugal fans made by The Standard & Pochin Bros. Limited, Evington Valley Road, Leicester, are available in all sizes from 6 in. up to 72 in. fan diameters. Full details of performances and leading dimensions are contained in publication No. 177A.

Stress-relieved Aluminium Plate for Aircraft

A guide to the use of thick, high-strength stress-relieved aluminium alloy plate in the aircraft industry has been published by Northern Aluminium Company Limited, Banbury, Oxfordshire under the title of "Noral Stress-relieved Plate".

This material forms the basis of a new technique of fabricating certain stressed parts of high-performance aircraft by integral construction, whereby wing skins, tail surfaces and similar parts are machined, complete with stiffening members, from solid billets instead of being made as a riveted assembly of small components. The booklet is intended to provide designers with information on the properties, sizes, manufacturing tolerances and inspection standards to which this plate is produced.

Extrusion Press Components

Amongst the many specialized steel products manufactured by Hadfields Limited, East Hecla Works, Sheffield 9, the containers, die holders, dies, press rams and other components of heavy extrusion press which they manufacture call for particular reliability to withstand very arduous and exacting working conditions. In their latest publication, No. 477 the material requirements of the components are discussed and recommended steels and their analyses are given.

Welding Insert Process

The E.B. weld insert process recently introduced to this country by Rockweld Limited, Commerce Way, Croydon, Surrey, is described in a new leaflet.

Used for pipe joints where a root run weld must be of the highest quality the E.B. weld insert comprises a wire of special section, which is fitted between the prepared ends of the pipes to be joined, and subsequently fused to provide a top quality weld, and a smooth contour both internally and externally. In the United States the insert has been used in the construction of nuclear-powered submarines.

New Factories

Billingham-on-Tees. Imperial Chemical Industries Limited, (General Chemicals Division) are to spend another £3,000,000 on further developments at their Cassel Works at Billingham.

Birtley (Co. Durham). Messrs J. Thorn & Sons Limited, portable buildings manufacturers, Bexleyheath, Kent, are erecting factory and offices at Birtley. The work is being done by direct labour.

Carlisle. West Cumberland Farmers Trading Society, Limited, Lowther Street, Whitehaven are considering acquiring a considerable site at the former Kingstown Airport for business purposes. Messrs. Harrison and Hetherington, Limited, Botchergate, Carlisle whose existing premises are affected by a road scheme are also interested in transferring some of their business to the Kingstown site.

Chester-le-Street. Plans have been approved for office block in Vigo Lane for British Oxygen Chemicals Limited.

Darlington. British Chrome and Chemicals Limited Sulphuric acid plant at Urlay Nook, near Darlington. The Power Gas Corporation, Stockton are supplying plant and equipment for the work; Redpath Brown and Co. Limited, Newcastle upon Tyne are the steelwork contractors while civil engineering work is being done by Tarslag Limited, Stockton, and Holst and Co. Limited, London.

The British Transport Commission. New buildings at Faverdale Wagon Works, to provide for offices, messroom, wash room, store, forge and smith's shop, and model and testing rooms.

The Post Office are to erect an engineering depot on a site of 10,000 sq yds on the McMullen Road trading estate.

Durham. The R.D.C. has approved amended plans for a proposed factory of 400,000 sq ft at Dragonville for Mackay & Co. Limited, carpet manufacturers. The first section of the work has been carried out by F. W. Goodyear and Sons, Claypath, Durham, in conjunction with Holst & Co. Waddington Street, Durham. No tenders have yet been obtained for further stages. The architects are Cordingley and McIntyre, Owengate, Durham.

Felling (Co. Durham) Road Services (Caledonian) Limited, Dumfries, The Kelvin Construction Company, Glasgow, are the contractors for the erection of a garage and distribution depot 300 ft long and 120 ft wide.

Ferryhill (Co. Durham). Ferguson Radio Corporation Limited, Enfield, Middlesex, propose factory additions covering 20,000 sq ft.

Gateshead. T. Robinson Son and Co. Limited. Construction of a large distribution depot in Hawks Road. The contractors are R. Bowey and Son Limited, 34 Great North Road, Newcastle upon Tyne. The architects are Elsworth Sykes and Partners, Scala Lane, Hull.

John Laing and Sons, Dalston Road, Carlisle have received a contract for the construction of an office block for British Road Services Limited, Team Valley.

Newcastle upon Tyne. Cackett, Burns Dick and Mackellar, 21 Ellison Place, Newcastle are preparing plans for fitting shop and offices in Albion Row for Domestos Limited.

Continued over

HEXAGONS
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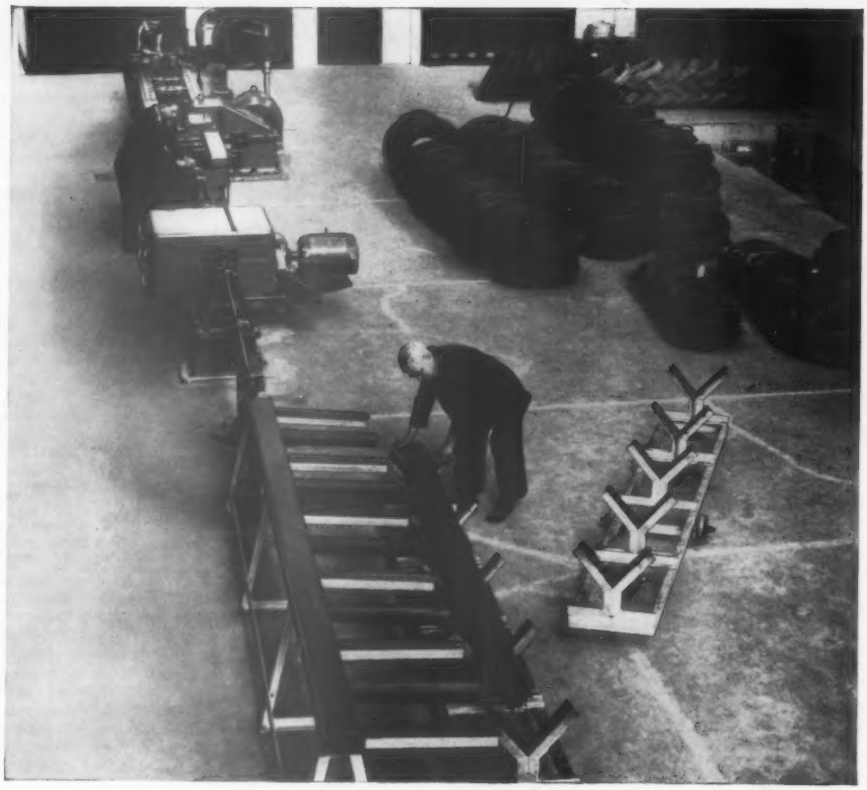
3" A/
TO
1/4" A/
DEPENDE
ON QUALI
& TREATME



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3 1/2
TO
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ON QUALI
& TREATME

DBS 100

South Shields. A factory extension is being carried out by the Tyne Chemical Co. Limited, River Drive. The general contractors are Alston Limestone Co. Limited, Westgate Road, Newcastle upon Tyne, while the steelwork contractors are Northern Tubular Buildings, The Close, Newcastle.

Stanley (Co. Durham). The Durham Coal Board, Beamish Hall, Stanley, are to reconstruct surface buildings at Beamish Mary Pit, Stanley.

Stockton-on-Tees. R. M. Douglas Limited, contractors, 27 Grange Road, Darlington are to erect a branch depot at Ross Road, and plans have been approved.

Tarslag Limited, public works contractors, Bowesfield Lane, Stockton are to erect a machine shop.

Sunderland. J. W. Thompson (Ironfounders) Limited. Office additions at Sheepfolds. Architects: Matkin and Hawkins, Bank Chambers, Fawcett Street.

Wallsend. D. Hill Porter and Co. (Newcastle) Limited, 14 Claremont Place, Newcastle upon Tyne are to erect an office block in the "G" pityard, and have prepared their own plans.

West Hartlepool. South Durham Steel and Iron Co. Limited. Office block. The contract has been let to John Laing and Sons, Dalston Road, Carlisle. The architects are Dodge and Reid, High Street, Brentford.

South Durham Steel and Iron Co. Limited. New slabbing and plate mills. Wimpey and Co. Limited, Newcastle upon Tyne have received the contract for the construction of foundations.

Aberdeen. Overhead Doors (Great Britain) Limited, Back Hilton Street. New factory.

Barking. Forrest Printing Ink Co. Limited. Plans have been approved for extensions to the factory in River Road.

Basildon. Bonallack & Sons Limited, extensions to factory.

Blackpool. The Mowbray Building Co. Limited, Mowbray Drive. New factory and offices.

Bristol. J. A. Venn Limited, 77 Ashgrove Road, Ashley Down. New factory and offices.

Sheldon Bush & Patent Shot Co. Limited. The factory in Cheese Lane is to be extended.

Burnley. Belling & Co. Limited. Extensions to their factory on the Heasandford industrial estate.

Chester. The Hydraulic Engineering Co. Limited. New factory on the Charles Street clearance area.

Coatbridge. S. H. McKinnon & Co. Limited, Montrose Works, Garfin. New factory at Shawhead.

Daventry. British Timken Limited, Braunston Road. Plans have been approved for extensions to factory.

Doncaster. British Ropes Limited. Erection of new factory at Carr Hill. Plans approved.

Dudley. Staffordshire Edge Tools Co. Limited. Extension of factory in New King Street.

Eastbourne. Turner Food Manufacturing Co. Limited. Extensions to the factory in Lottbridge Road.

Edmonton. Klinger Manufacturing Co. Limited, Silver Street. Works to be extended.

Enfield. Braham Patterson & Benham Limited, Strayfield Road. Architects of extensions to works are E. W. Palmer & Partners, 8 The Town.

Harlow New Town. Longmans, Green & Co. Limited, 6 Clifford Street, London, W1. New factory on the Western industrial estate.

Glasgow. Donaldson & Filer Limited. Extensions to the factory in Cogan Street.

Harwich. Vacuumatic Limited. Further extensions to the factory in Main Road, Dovercourt.

Hereford. Sweetman & Sons Limited. New factory at Plough Lane.

Hull. Zernys Limited, Clough Road works are to be extended.

Kew. Chrysler Motors Limited. Works extensions. Dodge & Reid, 72 High Street, Brentford are the architects.

Leamington Spa. Silver Knight Trailers Limited, 98 Warwick Road. New factory on the trading estate.

Loughborough. Graham (Jute) Limited. Extensions to their factory at 29 Farley Hill.

London. W. V. G. Engineering Co. Limited, Brentford. The architects for the new factory to be erected at Boston Park Road, London W4 are R. Sharp & Son, 13 Lower Belgrave Street, London, S.W.1.

Manchester. Brookes & Co. Limited, Sharston Road, Northenden. Extensions to biscuit factory. Architects: Taylor, Whalley & Spyra, 108 Portland Street.

Margate. Randolph Travel Goods Limited, 22 Cazenove Road, London, N16. New factory in High Street.

Mitcham. Chrome Print Limited, Eveline Road. Extensions.

Mortlake. Ruco Produce (Radio) Limited. Contractors for the new factory to be built in Lower Richmond Road are E. Gostling (Builders) Limited, 81 Whitton Road, Twickenham.

Redditch. George Homer (Redditch) Limited, Howell Road. Factory extensions.

Romford. Colvern Limited, Spring Gardens, London Road. Architects for new factory are J. W. Hammond, 20 North Street.

Sheffield. Brown Bayleys Steels Limited, Riverdale. New forge.

Tottenham. Brasted Bros. Limited, 167 Hermitage Road. Factory extensions.

Wakefield. Calder Vale Glassworks Limited. Extensions to the works and offices in Calder Vale Road.

Walthamstow. Bluestone & Elvin Limited. Extensions to the works in Hookers Road.

Watford. The Universal Asbestos Manufacturing Co. Limited, Tolpitts, propose a further mechanisation and additional production scheme.

Wembley. Carrier Engineering Company, The architects for factory extensions are Huckle & Durkin, 30 Queen Anne Street, London, W.1.

West Bromwich. Hill and Jackson Springs Limited. Extensions to factory.

Aberdeen. Timber Preservation (Aberdeen) Limited, Wellington Road, Craiginches, Aberdeen. New plant for fireproofing of timber.

Byron S. Bellamy, Aberdeen fish merchant, is to promote a quick-frozen project with assistance from the White Fish Authority. He leads a group of merchants interested in quick-freezing of fish. The plant now planned will take 625 tons.

Arbroath. William Sword Limited, of Groveside Bakery, Airdrie, is planning a 70 ft by 40 ft branch factory at Keptie Road/Gallowden Road, Arbroath. Factory space, refrigeration space and office accomodation is planned. Dean of Guild Approval has been given.

Blantyre—Industrial Estate. New factory for Turner Brothers (Birmingham) Limited, making tools, jigs, fixtures for Scottish users, and handling repair trade. Official opening of the factory scheduled for June 2nd.

New tool making plant for Turner Bros. (Birmingham) Limited, producing jigs, tools, fixtures.

Kilmarnock. Blackwood, Morton and Sons, Limited, carpet manufacturers of Kilmarnock, have been granted permission to erect a new spinning mill in Lawson Street. Estimated cost of the new mill is £10,000.

Kirkintilloch. Archibald Low and Sons Limited, Glasgow, engineers and plumbers, for marine purposes, plan a new factory at Kirkintilloch, employing some 400 workers.

Perth. Arthur Bell and Sons Limited, distillers, are to erect a new whisky blending and bottling warehouse at Perth to meet the expanding production of whisky from their main distilling units.

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Classified advertisements are inserted at the rate of 2/9 per line.

Situations Vacant

REQUIRED by Chester Waterworks Company—Foreman Fitter Mechanic, with experience of A.C. and D.C. electrically driven pumps, stationary diesel engines and generators, and pumps driven by same. Applicant should be capable of carrying out electrical and mechanical maintenance work on above and other sundry waterworks equipment. Permanent position, superannuation and sick pay schemes. Apply by letter to Engineer, Waterworks, Chester.

Machinery, Plant and Accessories For Sale

LARGE QUANTITY OF SECONDHAND RECONDITIONED GRAVITY ROLLER CONVEYOR FOR DISPOSAL

3500 Standard 8 ft lengths of Gravity Roller Conveyor, roolers 14 in. wide × 2½ in. dia. rollers set at 6 in. pitch, set in 2 in. × 1½ in. × ¼ in. angle iron frame, safe working load—50 lb per roller, complete with hooks and trunnion pins for coupling up. All in condition equal to new.

100—Lengths—ditto—but rollers set at 4 in. pitch.

250—Standard 8 ft lengths of Gravity Roller Conveyor, fitted Galvanized Rollers, 18 in. wide × 2½ in. dia., roller set at 6 in. pitch set in 3 in. × 2 in. × ¼ in. angle iron frame, in excellent condition.

300—7 ft 6 in. lengths—Gravity Roller Conveyor, rollers 18 in. wide × 2½ in. dia., rollers set at 6 in. pitch, set in 3 in. × 2 in. × ¼ in. angle iron frame, in excellent condition.

Large Quantity of Bends and Stands to suit above material.

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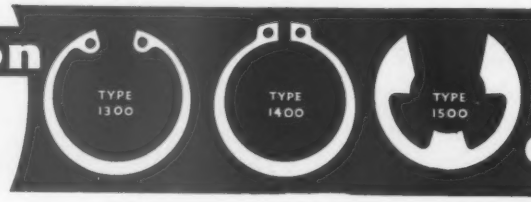

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